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A PHARMACOGNOSTICAL STUDY ON DATURA ALBA NEES AND DATURA FASTUOSA LINNÆUS FROM THE PHILIPPINES

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SEVEN PLATES

The genus *Datura* of the natural family Solanaceæ contains about ten species of plants distributed throughout the tropical and temperate regions. All are regarded as highly poisonous and some of them have been used for centuries for both criminal and medical purposes, especially in India and in the southern part of China. Of the ten species under this genus only two are found in the Philippines; namely, *Datura alba* Nees and *D. fastuosa* Linnæus. They are herbaceous plants about 1.5 meters high, and are commonly known as *talong-punay puti* and *talong-punay itim*, respectively, or *kachubung* in Visayan. The former grows throughout this country, in waste places, while the latter is generally cultivated, and both are extensively distributed in the Indo-Malayan Region, tropical Africa, and America; they are cultivated in the southern part of Europe. Merrill(10) believes that they may be of prehistoric introduction.

Safford,(11) working critically on the genus *Datura*, came to the conclusion that the true *Datura metel*, described by Linnæus in the first edition of his Species Plantarum, is a species based upon the Asiatic metel nut, or "jouz-methel," which was used as a narcotic by the Arabs, Persians, and Hindoos long before the discovery of America. He claims that *D. fastuosa* was a

form of this species but, because of its purple color and the reduplication of the corolla, it has been set apart as a distinct species, while the white-flowered form was rechristened *D. alba*.

Interesting accounts regarding the ancient knowledge of the properties of *Datura alba* Nees and *D. fastuosa* Linnæus are found in Arabic, Sanskrit, and Indian literature, which fully establish their uses from the remotest antiquity.

Flückiger and Hambury,(5) Ford and Crow,(6) and Watt(13), (14) give a rather complete description of the history, properties, uses, etc., of the two forms found in China and India. Many cases of poisoning with criminal intent are cited.

In the Philippines also the two plants, the white-flowered and the purple-flowered, have long been known for their medicinal and poisonous properties. The flowers are smoked as a remedy for dyspnea in bronchitis. Bowman(2) reported a severe case of poisoning from the seeds of *Datura alba* of this country and mentioned symptoms similar to those described in cases of poisoning in India.

The leaves of *Datura alba* are official in the French, Japanese, and Indian Pharmacopœias, and the leaves and seeds are official in the British Pharmacopœia. *Datura fastuosa*, or the black datura, has always been considered the more powerful or more poisonous of the two; but, according to the Pharmacopœia of India, there is no evidence that this is so, and probably both contain an equal amount of the active principle.

In connection with the active constituents Browne(3) in 1896 reported that the flowers of the Chinese *Datura alba* contain 0.485 per cent of alkaloid calculated as hyoscine. Hesse(9) in 1900, however, working with flowers provided by Browne, obtained 0.55 per cent of total alkaloids of which approximately 92 per cent was hyoscine, 6 per cent hyoscyamine, and 2 per cent atropine. Bacon(1) in 1906 obtained 0.465 per cent of total alkaloid from the air-dried seeds of the Philippine *Datura alba*, 0.21 per cent from air-dried leaves, and 0.17 per cent from air-dried wood and roots. Brill(4) in 1916 conducted a series of experiments upon the active principles of the same plant and obtained a greater percentage of total alkaloid than Bacon did. He claimed that prolonged drying and heating at high temperatures caused loss of the alkaloid.

In 1922, Garcia and Guevara(7) conducted very interesting experiments on the pharmacodynamics of *Datura alba* Nees and came to the conclusion that the effects of toxic doses in dogs and cats correspond to those produced in man. In large

doses it produces excitement, then incoördination and, lastly, depression with a tendency to sleep. These symptoms agree with those described by Tavera.(12)

It is strange, however, that the anatomical structures of such important plants as *Datura alba* Nees and *D. fastuosa* Linnæus, which have been fully recognized for centuries because of their valuable medicinal properties and as a poison, have received but little attention. It seems, therefore, that a critical pharmacognostical study of the two plants upon which the identification of the drug can be based is desirable.

MATERIALS AND METHODS

The materials used for the investigation of *Datura alba* were collected from wild plants growing about Manila and from cultivated ones in the botanical garden of the University of the Philippines. The sections used for *Datura fastuosa* were prepared from seeds collected from Puerto Galera, Mindoro, and from cultivated plants in the University grown from the same lot of seeds.

All the sections used were prepared from fresh material and cut from 20 to 50 μ thick by means of a sliding microtome. Some were mounted in a dilute solution of glycerine, some in a dilute solution of chloral hydrate, and some were stained with safranine, contrasted with hæmatoxylin, and mounted in balsam. For the detailed study of the seed coat, Schulze's maceration process as indicated by Greenish(8) was employed.

DATURA ALBA NEES

The leaves.—The full-grown leaves are from 9 to 18 cm long and from 7 to 14 cm wide. They are ovate to oblong-ovate in outline, petiolate, nearly glabrous, and when fresh are dark green in the upper surface and light green in the lower surface (Plate 1, figs. 1 and 2). The base is unequal, one side extending 3 to 12 mm below the other, but occasionally is even and rounded. The margin is irregularly and shallowly lobed. The lobes vary in number from two to five on each side of the leaf, and have rather obtuse or sometimes slightly rounded tips. The apex of the leaves is generally acuminate, but occasionally shortly pointed. The petioles are from 6 to 12 cm in length, nearly cylindric, shallowly grooved on the upper part, and light green like the midrib and veins. On the projecting midrib there are veins of the first order, four or five in number, diverging from it at an angle of 30 to 75 degrees, dividing near the margin, and

the outer lateral branches passing into the lobes. The other lateral branches of these primary and secondary veins anastomose with each other, forming a sort of network. When the fresh leaves are crushed between the fingers they throw off a somewhat disagreeable, narcoticlike odor. The taste is unpleasant, bitterish, and nauseating.

The young leaves are usually more or less entire and covered with rather thick hairs, but as they progress toward maturity they become more or less glabrous.

Structure of the leaf.—The leaf structure of *Datura alba* Nees in cross section is bifacial and has the general appearance of a cross section of the leaf of *Datura stramonium*, but differs from it in several respects (Plate 2, fig. 21). The mesophyll is rather uniform in thickness, which is about 0.35 mm. The upper epidermis is composed of a single layer of tangentially elongated and rectangular cells with thick and cutinized outer cell walls. The lower epidermis also consists of a layer of cells, of the same shape but with very much thinner and less cutinized outer cell walls. The palisade chlorenchyma occupies about one-third of the section and consists of a single row of perpendicularly elongated cells about 0.1 mm in length and 0.025 mm in diameter and formed just below the upper epidermis. In the lower part two or three of these cells communicate with one large cell which frequently contains a rosette-shaped crystal or a rosette aggregate of crystals of calcium oxalate, and can be called a crystal cell. The crystal cells form part of the spongy chlorenchyma region. They are characterized not only by their rosette-shaped crystal content but also by their relatively large size and comparatively isodiametric shape. They usually form a continuous row in the interneural region and form a part of the spongy region. They are about 0.041 mm in diameter (Plate 2, fig. 21 *cr*). The spongy chlorenchyma region is made up of spongy parenchyma cells of various forms and sizes, but in general they are more or less elongated with a slightly wavy outline and with few chloroplastids. This part of the mesophyll is a trifle wider than the palisade region, and is richly supplied with large air spaces. Epidermal outgrowths are observed on upper and lower sides consisting of (*a*) warty, uniserial, articulated, nonglandular hairs of 3 to 5 cells and from 0.6 to 0.9 mm in length, and (*b*) glandular hairs with a slightly bent, 1-celled stalk and with a 4- to 6-celled secreting head. The capitate part or gland is usually globose in outline, and is mostly 4-celled. These glandular hairs measure from

0.06 to 0.08 mm; the stalk is 0.035 mm long, and the diameter of the gland is about 0.034 mm.

In the surface preparations the upper epidermal cells appear polygonal in outline with slightly wavy or undulate thick walls, and are from 0.054 to 0.095 mm in length and from 0.036 to 0.05 mm in width. The lower epidermal cells are also more or less polygonal in outline, but their walls are thinner and distinctly undulate-sinuate (Plate 2, figs. 22 and 23). The stomata are more numerous in the lower surface and vary from 0.029 to 0.036 mm in length and from 0.016 to 0.026 mm in width, and three or four and, occasionally, five neighboring cells surround them. One of the neighboring cells is invariably smaller than the others, and this smallest neighboring cell is usually applied vertically to the length of the guard cells. The glandular and nonglandular hairs are better noted in these preparations. They are more abundant in the lower surface, particularly along the sides of the veinlets.

When the surface sections are cleared with an aqueous solution of chloral hydrate the epidermal cuticle is observed to be distinctly striated. This striation of the cuticle is more evident on the lower surface than on the upper. The striated lines all run in a given direction (that is, parallel to the longest side of the epidermal walls) and apparently converge to the base of simple hairs or sometimes are perpendicular to the length of the guard cells of the stomata, as represented in Plate 3, figs. 24 and 25.

The midrib is convex above and strongly convex below (Plate 2, fig. 21). The ventral epidermis as well as the dorsal consists of a single layer of nearly isodiametric cells, square or nearly circular in outline. Occasionally they are somewhat radially elongated, particularly those of the lower side. They are from 0.015 to 0.04 mm in diameter. The outer cell walls of the upper epidermis are comparatively thicker and more cutinized than are those of the lower epidermis. The stomata and the glandular and nonglandular hairs are found in both the upper and the lower epidermis. The collenchyma cells are present in two distinct groups, above and below the midrib. In the inner part of these cells toward the stele is a region of cortical parenchyma consisting of several rows of large cells, 0.03 to 0.09 mm in diameter, some of which are filled with very abundant sphenoidal microcrystals of calcium oxalate; the rosette, prismatic, or rhomboid crystals are also seen, but they are less numerous. The endodermis is not distinct. The meristele is

somewhat crescent-shaped or it appears as a flat arc in outline. The xylem is composed of large vessels, from 0.02 to 0.05 mm in diameter, and is provided with bast in the exterior part above and below, which is a constant characteristic of plants belonging to the family Solanaceæ. Neither sclerenchymatous elements nor pericycle fibers are found in the bast.

The petiole.—The structure of the petiole in cross section is very similar to that of the midrib, except that the outline of the petiole is somewhat circular. There is only a slight indication of the shallow groove found along the upper part of the petiole. The principal meristele has a U shape. Near the region corresponding to the upper lateral side of the groove there appear two apparently isolated incipient vascular bundles, one on each side of the raised part, consisting of xylem and phloëm. The central upper portion of the groove corresponding to the convex upper side of the midrib is slightly convex, and contains typical subepidermal collenchyma cells.

The flowers are very large, white, solitary, axillary, and shortly pedicelled in the forks. They are from 12 to 18 cm long. The pedicel is green, terete, and from 6 to 10 mm long. The calyx is about 6.5 cm long or more, pale green, thin, slightly hairy, tubular, with five short, more or less triangular lobes, from each of which a distinct ridge runs down to the base. It is deciduous by a transverse circular fission or cleavage near the base, the upper, thinner portion falling off, while the thicker, small, basal part remains persistent with the fruit (Plate 1, fig. 1).

The corolla in the bud is longitudinally plicated. When expanded it is white, slightly fragrant, tubular-funnel-shaped, 15 to 18 cm long and 10 cm wide at the mouth. It has five plaits and five spreading or recurved lobes. The lobes are somewhat rounded, but their middle parts are provided with acuminate, almost filiform, cuspidate points, from 1 to 2 cm in length. When the young ovary begins to divide into nodes the corolla gradually separates at the very base and falls off together with the five epipetalous stamens and the deciduous calyx.

There are five stamens, inserted in the corolla tube; the anthers are elongated, flattened, dorsifixed, hairy, from 14 to 16 mm long, and dehiscing longitudinally (Plate 1, figs. 3 and 4). The filaments are about 14 cm long. The pollen grains are globular or sometimes ovoid, whitish, finely striated, and from 0.035 to 0.05 mm in diameter when dry and from 0.065 to 0.075 mm when mounted in water (Plate 1, figs. 5*a*, 5*b*).

The pistil is characterized by the very long, filiform, whitish

style, which is from 12.5 to 18 cm in length; by the bilateral or bilobed blunt stigma, which is about 5 mm long; and by the superior, conical, 2-carpelled ovary, which is seated on a disk of the nectary gland and covered with somewhat erect processes (Plate 1, fig. 6).

The ovary is 2-celled above and imperfectly 4-celled below, due to the outgrowth of a false dissepiment from the dorsal suture of the carpels to the axile placentæ (Plate 1, figs. 7 and 8). Ovules anatropous, very numerous, and arranged in a very irregular manner.

Surface preparation of the calyx and corolla.—The outer epidermal cells of the calyx have the general appearance of the upper epidermal cells of the leaf, except that they are smaller. They are more or less polygonal in outline, 0.018 to 0.075 mm in length, and 0.018 to 0.036 mm in width. The stomata are numerous and vary from 0.03 to 0.4 mm long and from 0.02 to 0.025 mm wide. Both glandular and nonglandular hairs are present. The glandular hairs, like those found on the leaf, consist of a slightly bent, 1-celled stalk with four to eight secreting head cells; the usually bent nonglandular hairs are 0.15 to 0.25 mm long and composed of three or four warty cells (Plate 3, fig. 26). The inner epidermal cells are also somewhat polygonal in outline, but are larger and have thinner and distinctly undulate cell walls. They are from 0.036 to 0.124 mm in length and from 0.018 to 0.072 mm in width. The stomata are also present, but are comparatively larger and less numerous, and some of them are aborted at different stages. The fully developed stomata are from 0.04 to 0.055 mm in length and from 0.03 to 0.035 mm in width. The two kinds of hairs are not found on the inner side of the calyx (Plate 3, fig. 27).

The outer and inner surface views of the corolla are practically the same in appearance. The cells are polygonal in outline, 0.029 to 0.072 mm in length and 0.022 to 0.036 mm in width, and have slightly undulate thin walls (Plate 3, fig. 28). Both glandular and nonglandular hairs are present on the two sides. There are two kinds of glandular hairs, however, one with the same characteristics as those already described in the leaf and calyx (Plate 3, fig. 29); another with a 3- to 5-celled stalk, in which the basal cell is strongly developed and has a single terminal secreting cell, as indicated in Plate 3, figs. 30 and 31. The latter type of glandular hairs is seen only on the corolla. They are comparatively longer than the nonglandular hairs of the leaf and have large basal cells with thick walls.

These glandular hairs are about 0.3 mm in length, and their basal cells are about 0.04 mm in diameter.

The fruit.—The fruit is globose or sometimes ovoid, about 3.5 cm in diameter, nodding, green, covered with short, stout spines, and surrounded at the base by the enlarged and usually reflexed persistent base of the calyx. It is distinctly and practically bilocular, although the 2-axiled placentæ project into the interior of the loculi. No secondary dissepiment extends in the part between the fleshy placentæ and the opposite wall of the fruit. The pericarp is fleshy, soft, and easily disintegrated when pressed between the fingers. It is always apically or subapically dehiscing into four or more irregular valves, as indicated in Plate 1, fig. 9.

The seeds.—The mature seeds of *Datura alba* Nees are light yellowish brown, very irregular in shape, somewhat shriveled, flattened, and have the general appearance of the human ear. Sometimes they are obscurely triangular or subreniform in outline, one end smaller than the other (Plate 1, figs. 10 and 11). They are from 5 to 6 mm long, 4 to 5 mm wide, and 1.5 to 2 mm thick. The dorsal side or rounded end is thickened and distinctly sinuous, convoluted, double- or triple-ridged, with one or two deep grooves along the middle part. The hilum is rather prominent and, when fresh, is white. It runs from the pointed or micropylar end to nearly half the length of the seed. The outer surface of the testa, as seen under the hand lens, exhibits fine rugosities but is not prominently pitted.

Microscopical structure.—A median longitudinal section of the seed, cut in a plane parallel to the flattened surface, as represented in Plate 1, fig. 12, a diagrammatic drawing made under the objective 48 mm and eyepiece × 2 with the aid of a camera lucida, shows at least four distinct regions; namely, the seed coat region; the endosperm region, which is somewhat reniform in outline; the coiled embryo, which is extended around the peripheral side of the endosperm and shows the two bent cotyledons, the plumule, and the radicle; and the hilum, which is located toward the pointed or micropylar end of the seed. To these four regions the perisperm may be added, which under a higher magnification can be seen between the seed coat and the endosperm. In a more or less transverse or oblique section, cut at right angles to the flattened surfaces and somewhat obliquely to the long axis of the seed, only three of these important regions are seen in Plate 1, fig. 13. The section appears as oblong-elliptic in outline, slightly constricted at the

middle, and coarsely crenated at the two ends, corresponding to the ventral and dorsal parts of the seeds. The crenation is simply due to the folding of the epidermal layer at the two regions where the epidermal cells are greatly elongated. The epidermis corresponding to the flat surfaces is comparatively thinner, and the length of the epidermal cells gradually increases toward the two ends. The endosperm is also oblong-elliptic, and somewhat constricted at the middle part. The embryo is cut into two pieces. Toward the dorsal region of the endosperm the cross section of the radicle is found; and toward the ventral side, the transverse section of the two cotyledons.

Careful examination of thin sections of the seed reveals that the region of the seed coat is differentiated into three somewhat distinct layers; namely, the outer layer, or testa, the layer next to the testa, and a layer made up of collapsed or obliterated parenchyma cells.

The outer layer, which constitutes the testa, consists of a single row of radially and tangentially elongated, thick-walled, greatly lignified, and tangentially pitted cells. Its external part is lined with a thin layer of a hyaline substance of mucilaginous nature. In the transverse or longitudinal section cut parallel to the plane of the flat surface of the seed, these cells appear very irregular in outline. They vary from isodiametric to rectangular or bottlelike or stonelike cells with a minute projecting outgrowth toward the outer and inner ends. Their walls are sinuously bent in and out in the direction of their length as shown in Plate 1, figs. 14 and 17. The cells that correspond to the flattened side have the general characteristics and shape of the ordinary stone cells, with distinctly striated thick walls and small cavity. Sometimes they are tangentially compressed or elongated, papillate or with minute processes in the outer part like the other cells of the testa (Plate 1, fig. 16).

In surface view the elongated cells as well as the flattened ones are polygonal in outline and appear indented with one another. Their walls are wavy and distinctly striated. The indentations of the cells are found to be somewhat interlacing along the middle lamella, and appear as very minute, thick-walled cells, elliptic in outline, as illustrated in Plate 2, fig. 19. The transverse sections of the seed coat cut tangentially to the dorsal part of the seed show that the very thick, lignified cell walls are closely fitted to each other with a distinct, middle lamella, striated and differentiated into two regions. The sections made toward the outer part show that the cells have

thinner walls, and eventually larger cavities; on the other hand, in the sections cut through the middle part of the cells corresponding to the constricted region, the cells have a smaller cavity and very thick walls. Figure 20 (Plate 2) is drawn from the tangential sections of the dorsal side of the seed.

When this outer layer of the testa is macerated by Schulze's maceration mixture, the individual cells exhibit great diversity in size and form. The cells from the flattened regions of the seed are easily identified as they are very short and very irregular in outline. They are from 0.08 to 0.18 mm in diameter and from 0.15 to 0.21 mm in length. The stonelike cells, besides exhibiting the general characteristics already described, show that their cell walls are almost uniformly thickened all around and more or less distinctly striated, and they have very small lumens, or cavities. The cup-shaped, or beakerlike, cells are more regular in shape and somewhat rectangular in outline. They are usually slightly constricted at the middle part. Their cell walls are also transversely pitted, striated, and greatly thickened in the lateral parts, particularly at the constricted region, but they gradually become thinner toward the two ends of the cells where the indentations or processes are observed. The epidermal cells corresponding to the corrugated or convoluted regions of the seed are radially elongated, more regular in outline, and all are transversely pitted. They are 0.082 to 0.18 mm in diameter and from 0.285 to 0.378 mm in length. These cells also appear cup-shaped and are indented in both outer and inner ends like the other type of cells found in the flattened side of the seed, except that they are more elongated and more constricted in the middle part. Sometimes the constriction is extended toward the base, and the cells simulate a certain kind of flower base or are somewhat like a funnel, as shown in Plate 2, fig. 18, *a* to *g*. Their side walls are distinctly striated and greatly thickened, particularly toward the constricted part, but gradually become thinner toward the transverse walls. The pits, which run transversely, occur in the thickened part, but they are more abundant toward the thinner walls. The reticulate markings or the scalariform thickenings are frequently observed among the large cells. They are transversely arranged throughout the entire length of the cells. A microchemical test upon the walls of these cells of the testa showed that they are lignified.

The layer next to the testa consists of two or more rows of parenchyma cells with thin, delicate, and slightly wavy cell

walls (Plate 1, fig. 14*p*). They are more or less isodiametric and rather well preserved, with somewhat triangular intercellular spaces at the point of meeting of three adjacent cells.

The third layer of the seed coat is made up of collapsed or obliterated parenchyma cells, with extremely thin and delicate cell walls (Plate 1, fig. 14*op*). On account of the compactness of their walls, it is difficult to determine either the structure of the individual cell or the number of rows of these cells that form this layer.

The perisperm.—Between the layer of the obliterated parenchyma of the seed coat and the epidermis of the endosperm is a single row of rather tangentially elongated or somewhat rectangular thin-walled cells. These cells are the remains of the nucellus and they are more or less hyaline in nature. They constitute what is known as perisperm, which closely adheres to the outer part of the endosperm (Plate 1, fig. 14*pe*).

The endosperm.—The endosperm is composed of rather large, nearly isodiametric cells with fairly thick walls, mostly polygonal in outline, and filled with rather large aleurone grains, and sometimes with oil globules. The cells toward the periphery, however, are radially elongated, as shown in Plate 1, fig. 14*e* (a drawing made from a transverse section) and fig. 15 (a cell drawn from the middle part of the endosperm, greatly enlarged, showing aleurone grains and oil globules). Within the endosperm the sections of the embryo are embedded. The cross section of the radicle is circular in outline, and is composed of young, undifferentiated tissue consisting of parenchyma cells filled with small aleurone grains. The region occupied by the cortex and that occupied by the stele are very distinct, while the transverse sections of the cotyledons are somewhat elliptic in outline and are obscurely differentiated into epidermis, palisade and spongy parenchyma, and rudimentary vascular bundles. The cells are isodiametric and also filled with small aleurone grains, as are those of the radicle (Plate 1, fig. 13).

DATURA FASTUOSA LINNÆUS

The leaves.—The mature leaves are from 8 to 17 cm long and from 6 to 12 cm wide. They are ovate in outline, petiolate, glabrous, and dark green on the upper surface and light green on the lower surface (Plate 4, figs. 33 and 34). The margin is entire or sometimes slightly lobed. The lobes vary from one to three or more, with obtuse or rounded tip. The base is unequal, one side extending from 4 to 17 mm below the other.

The apex is generally acuminate and sometimes acute. The petioles are from 3 to 8 cm in length, nearly cylindrical, shallowly grooved on the upper part, and purple in color or sometimes greenish spotted with purple. The projecting midrib and the four or five veins of the first order are entirely purple or sometimes only spotted with this color. These veins diverge from the midrib at an angle of 30 to 50 degrees and divide near the margin. The secondary veins and the veinules anastomose, forming a sort of network. The fresh leaves, when crushed between the fingers, like the fresh leaves of *Datura alba*, throw off a somewhat disagreeable narcoticlike odor. The taste is unpleasant, bitterish, and nauseating.

The leaves of *Datura fastuosa* are darker and rather smaller and thinner than those of *Datura alba*. The margins of the former are very shallowly lobed and sometimes they are entire, while those of the latter are usually lobed, and the lobes are distinct.

Structure of the leaf.—The leaf structure of *Datura fastuosa* is very similar to that of *Datura alba* (Plate 6, fig. 62). The only difference is that the mesophyll of the former is thinner and the palisade chlorenchyma cells are smaller, from 0.05 to 0.07 mm in length and about 0.02 mm in diameter. Both glandular and nonglandular hairs are present in the upper and lower surface of the leaf. These hairs differ from the hairs of *Datura alba* in that the stalk of the glandular hair is usually straight and sometimes consists of two cells, while that of *Datura alba* is slightly bent and usually consists of a single cell; the nonglandular hairs of *Datura fastuosa* are generally shorter than are those of *Datura alba* (Plate 7, figs. 63 and 70).

In the surface preparations mounted in dilute glycerine, the upper epidermal cells of *Datura fastuosa* appear practically like the upper epidermal cells of *Datura alba* as shown in Plate 7, figs. 63 and 64. In the lower epidermis the cells of the former are larger than are those of the latter and they have thinner and more-wavy cell walls. The stomata are also less numerous and they vary from 0.12 to 0.165 mm in length and from 0.09 to 0.1 mm in width.

In the surface preparation cleared with a dilute solution of chloral hydrate the epidermal cuticle is observed to be more striated than is that of *Datura alba*, as shown clearly in Plate 7, figs. 65 and 66.

The structure of the midrib coincides in every respect with that of *Datura alba*, except that the vessels are slightly smaller,

and the sphenoidal microcrystals and the prismatic crystals of calcium oxalate are more abundant (Plate 6, fig. 62).

The petiole.—I failed to find any significant differences in the structure of the petioles of the two plants. Both have practically the same distribution of tissues and the vessels are very similar.

The flowers.—The flowers of *Datura fastuosa* are strikingly different from those of *Datura alba.* They are very large, with double or triple corolla, purple, solitary, in the forks, and shortly pedicelled. They are from 16 to 19 cm long. The pedicel is purple, or sometimes greenish purple on one side, terete, and from 4 to 8 cm long. The calyx is about 5.5 cm long, greenish, with numerous elongated purple spots which occasionally unite and form a large purple area. It is thin, slightly hairy, tubular, with five short, more or less triangular lobes, from each of which a distinct ridge runs down to the base. Like that of *Datura alba,* it is deciduous by a transverse circular fission or cleavage near the base, the upper thinner portion falling off, while the thicker, small, basal part remains persistent with the fruit like a ring (Plate 4, figs. 33 and 35).

The corolla is the most variable part of the purple-flowered *Datura.* In the bud it is plicated, but when expanded it is tubular-funnel-shaped, 15 to 18.5 cm long, and about 6 cm wide at the mouth. The upper outer surface is violet or dark purple, which color gradually becomes lighter toward the lower part and finally greenish white at the base, while the inner surface is white. It is usually doubled or tripled, and sometimes in the latter form between the second and third corolla there are linear appendages or petal-like structures like those shown in Plate 4, figs. 36 and 37. The outer corolla is usually separated or free from the inner ones, which are always united near the base. The corolla has five plaits and five more or less convoluted lobes with acuminate, filiform cuspidate and twisted points which are about 2 cm long. When the corolla begins to bend downward, as in the case of *Datura alba,* it gradually separates at the very base and falls off together with the five epipetalous stamens and the deciduous calyx.

The five stamens inserted in the corolla tube have elongated, somewhat flattened, dorsifixed, hairy anthers, 14 mm long, which dehisce longitudinally (Plate 4, figs. 36 and 38). The filaments are filiform, about 15 cm long. The pollen grains have the general appearance of those of *Datura alba,* are finely striated and from 0.032 to 0.05 mm in diameter when dry and about 0.07

mm in diameter when mounted in water (Plate 4, figs. 39*a* and 39*b*).

Many abnormalities were observed in the development of the flowers of *Datura fastuosa* which I have never observed in those of *Datura alba*. The corolla tube is sometimes folded and twisted at the middle part. This happens while the corolla is still inclosed by the calyx, so that as a result, when it begins to expand, the calyx is burst or split down one side, as shown in Plate 5, figs. 46 to 50. From the early stage of the corolla, especially when it commences to protrude from the calyx, it can be predicted whether it will be a normal or an abnormal corolla, because of the irregularity of the diameter of the calyx (Plate 5, figs. 48, *a* and *b*). The abnormally borne flowers are always smaller than the normal ones and their stamens are usually abnormal, as shown in Plate 5, figs. 50, *a* and *b*. Occasionally the stamens are united at the base, and frequently the filaments are provided with appendages, or winglike structures (Plate 4, figs. 43 and 44; Plate 5, figs. 49, *a* and *b*), but the anthers are not affected by this abnormality. A very serious case of the abnormally borne flower is shown in Plate 5, fig. 47, where the outer corolla is also burst at one side near the base, and the folded and twisted part of the inner corolla is protruded, together with the stamens in it.

The pistil is filiform, whitish or sometimes purplish, and about 14.5 cm long, while the bilateral stigma is about 6 mm long. It is apparently not affected by the abnormalities just mentioned, and the vitality of the ovary is not lost (Plate 4, fig. 40).

The ovary is covered with flat processes and these are usually less numerous than those observed in *Datura alba*. It is also 2-celled above and imperfectly 4-celled below, as shown in Plate 4, figs. 41 and 42.

The surface preparation of the calyx and corolla.—In structure the outer and inner surfaces of the calyx agree well with those of the calyx of *Datura alba*. Only slight difference is observed in the size and shape of hairs and stomata and in the thickness and outline of the inner epidermis. The nonglandular hairs of *Datura fastuosa* are shorter, consist of two to four cells, and are mostly straight. They are from 0.1 to 0.15 mm long and are not very abundant. The stomata are elliptic and from 0.025 to 0.045 mm long, 0.025 to 0.030 mm wide. The cell walls of the inner epidermis are more wavy and are thinner than those of *Datura alba* (Plate 7, figs. 67 and 68).

The epidermal cells of the corolla have thinner and more-wavy cell walls than have those of *Datura alba*. Both glandular and nonglandular hairs are observed. The long-stalked, glandular hairs are 0.15 to 0.4 mm long, and the cell walls of their two basal cells are not thickened, as shown in Plate 7, fig. 69.

The fruit.—The fruit is almost identical with that of *Datura alba* in shape, size, structure, and method of dehiscing, except that it has usually a smaller number of spines, or sometimes is spineless and smooth (Plate 4, fig. 45; Plate 5, fig. 46). Frequently its spines are confined simply to one side and it is smooth on the other side, particularly near the apex. The fruits derived from the abnormally borne flowers, however, are generally smaller than those developed from the normal ones.

The seeds.—The seeds of *Datura fastuosa* are thinner, flatter, and rather darker than are those of *Datura alba*. They are pale brown, discoidally auriculiform, 5 to 6 mm long, 4 to 5 mm broad, and 1.2 to 1.6 mm thick (Plate 6, figs. 51, *a* and *b*). When fresh, the fleshy outgrowth at the base is white and extends from the micropylar end to a little beyond half the length of the seed. The testa is rough, tough, and shriveled, with conspicuous double or triple convolutions and one or two main grooves along the dorsal side. Under the hand lens the outer surface of the testa is finely rugose, but is not distinctly pitted.

Microscopical structure.—Sections of the seeds of *Datura fastuosa* corresponding to the longitudinal and transverse sections of *Datura alba* seeds show the same characteristics and distribution of tissues observed in the latter (Plate 6, figs. 52 and 53). The indefinite embryo of *Datura fastuosa*, however, although its characteristic curvation is similar to that of *Datura alba*, can be easily differentiated from the latter by the fact that the tips of the pair of cotyledons of the embryo of *Datura fastuosa* and the lower end of the radicle are always very close together and almost touch each other.

In a critical study, however, made on thin sections of the seed-coat region, endosperm, embryo, hilum (and including the perisperm), as shown in Plate 6, figs. 54 to 60, I found that the structure of these regions is essentially the same as is the structure of the corresponding regions described in *Datura alba* seeds. The individual cells isolated by Schulze's maceration mixture exhibit the same characteristic markings on their walls and similar diversity in size and form. Although sometimes they appear rather smaller than the individual cells of *Datura*

alba, yet this variation in size cannot be relied upon as a diagnostic characteristic of the drug (Plate 6, figs. 61, *a* to *h*).

The calcium oxalate crystals.—The calcium oxalate crystals observed in the study of the two plants are rather similar in their general characteristics. They vary from very minute sphenoidal microcrystals, about 0.0025 mm long, to a large prismatic or monoclinic crystal, 0.05 mm long and 0.02 mm in diameter. The crystals of calcium oxalate found in the sections of the blade are usually two types of rosette; one is smaller, 0.012 mm in diameter and is made up of small sphenoidal microcrystals, as shown in Plate 3, fig. 32*b*, and Plate 7, fig. 74*c*, while the other is larger and is made up usually of larger, sphenoidal, prismatic or rhomboid crystals, as represented in Plate 3, figs. 32, *d* to *g*, and Plate 7, figs. 74, *e* to *h*. The rosette crystals of *Datura alba* are generally larger than are those of *Datura fastuosa* (Plate 3, fig. 32, and Plate 7, fig. 74). The crystals of calcium oxalate of the transverse section of the midrib are usually in the form of microcrystals which fill up some of the parenchyma cells in the upper and lower part of the vascular region (Plate 2, fig. 21, and Plate 6, fig. 62). There are also some rosette, prismatic, and rhomboid forms, but in *Datura fastuosa* the last-named forms are more numerous than in the sections of *Datura alba*.

SUMMARY AND CONCLUSIONS

1. Grown under the same conditions, the leaves of *Datura alba* are generally larger, thinner, more distinctly lobed, and lighter in color than those of *Datura fastuosa*, and the veins of the latter are purple.

2. The leaf structure of *Datura alba* is similar to that of *Datura fastuosa*, but the latter has a thinner mesophyll, shorter nonglandular hairs, and the stalk of the glandular hairs is usually straight and sometimes consists of two cells, while the stalk of the glandular hair of the former is slightly bent and usually consists of a single cell.

3. In the surface preparation of the leaf the lower epidermal cells of *Datura fastuosa* are larger and have thinner and more-wavy cell walls than those of *Datura alba*, and the stomata are less numerous than in the latter.

4. When the surface preparation is cleared with a dilute solution of chloral hydrate, the epidermal cuticle of *Datura fastuosa* is more striated than is that of *Datura alba*.

5. The cross section of the midrib of *Datura alba* has slightly larger vessels, and the sphenoidal microcrystals and prismatic

crystals of calcium oxalate are less abundant than are those of *Datura fastuosa.*

6. The flowers of *Datura alba* are white and slightly fragrant and the corolla is simple, with five spreading or recurved lobes, while those of *Datura fastuosa* are purple or violet on the outer surface and whitish on the inner surface. The corolla of the latter is usually doubled or tripled, with five convoluted lobes, and not recurved as in the former. Furthermore, the variability of the flowers of *Datura fastuosa* is not confined to the reduplication of the corolla, but also is noted in the production of appendagelike structures between the second and the third corollas, and also in the filament of the stamens in the abnormally borne flowers. This abnormality is not observed in the case of *Datura alba.*

7. The epidermal cells of the corolla of *Datura alba* have thicker and less-wavy cell walls than have those of *Datura fastuosa,* and the long-stalked, glandular hairs of the former are longer and provided with thick-walled basal cells, while those of the latter are shorter and the cell walls of the basal cells are thin.

8. The ovary of *Datura alba* is covered with numerous erect and pointed processes, while that of *Datura fastuosa* has few flattened processes.

9. The calyx of *Datura alba* is longer than is that of *Datura fastuosa.* That of the former is usually about half as long as the corolla tube, while that of the latter is about one-third of the corolla tube. The nonglandular hairs of *Datura alba* are longer than are those of *Datura fastuosa.*

10. The fruits of *Datura alba* are similar in shape, size, structure, and method of dehiscing to those of *Datura fastuosa,* except that the latter have fewer spines or sometimes are spineless and smooth.

11. The seeds of the two plants are the same in general appearance, but those of *Datura fastuosa* are thinner, flatter, rather darker, and smoother than the seeds of *Datura alba.*

12. In the longitudinal section of the seeds, cut in the plane parallel to the flattened surface, although the characteristic curvation of the embryo of *Datura alba* is similar to that of *Datura fastuosa,* that of the latter can be easily identified because the tips of the pair of cotyledons and the lower end of its radicle are closer than are those of the former, and sometimes they almost touch each other.

13. The microscopical structures of the seeds of the two plants are almost identical. The testa is their most important characteristic. It consists of radially and tangentially elongated, thick-walled, greatly lignified, and tangentially pitted cells. In the inner part of the testa there are layers of parenchyma and obliterated parenchyma cells. Between these cells and the epidermal cells of the endosperm the perisperm is found. The endosperm cells are more or less polygonal in outline and filled up with aleurone grains and some oil globules.

14. The calcium oxalate crystals are generally the same in appearance in both plants. In the midrib of *Datura fastuosa*, however, the sphenoidal microcrystals and the prismatic and rosette forms are more abundant than in the midrib of *Datura alba*.

ACKNOWLEDGMENTS

I am indebted to Dr. Leon Ma. Guerrero for suggestions, and to Dr. Lino José for the use of his unpublished work on *Datura alba* Nees for reference purposes.

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ILLUSTRATIONS

[All microscopic drawings by the author. The macroscopic drawings for Plates 1, 4, and 6 were made by Macario Ligaya, of the Bureau of Science. The photographs for Plate 5 were made by Jesus Redondo, of the Department of Botany, University of the Philippines.]

PLATE 1. DATURA ALBA NEES

FIG. 1. A habit sketch of a portion of the plant. × ⅓.
2. A full-grown leaf. × ½.
3. The corolla split down one side and spread, showing the five epipetalous stamens. × ½.
4. A stamen before dehiscing; *a*, ventral view; *b*, dorsal view. × 1½.
5*a*. Pollen grains as they appear when mounted dry. × 200.
5*b*. Pollen grains as they appear when mounted in water. × 200.
6. A pistil with a portion of the style removed; *c*, basal portion of calyx; *co*, basal portion of corolla; *ng*, nectary gland; *o*, ovary with sharp erect processes; *s*, basal part of style; *st*, stigma. × 2.
7. A transverse section from the upper part of an ovary, diagrammatic drawing. × 5.
8. A transverse section from the lower part of an ovary, diagrammatic drawing. × 5.
9. A mature fruit showing method of dehiscing. × ½.
10. Mature seed, lateral view. × 2¼.
11. Mature seed; *a*, ventral view; *b*, dorsal view. ×2½.
12. Diagrammatic drawing of a median longitudinal section of a seed, cut in the plane parallel to the flat surface; *sc*, seed coat; *e*, endosperm; *em*, embryo; *h*, hilum. × 4½.
13. Diagrammatic drawing of a transverse section of a seed, cut at right angles to the flat surface: *sc*, seed coat; *e*, endosperm; *ct*, cotyledons; *r*, radicle. × 4½.
14. A thin transverse section through the seed coat and endosperm; *t*, testa; *p*, parenchyma region; *op*, obliterated parenchyma region; *pe*, perisperm; *e*, endosperm. × 68.
15. A highly magnified drawing of an endosperm cell; *og*, oil globule; *a*, aleurone grains. × 280.
16. A small portion of the seed coat from a transverse section of the seed near the region of the flat surface. × 68.
17. A small portion of the seed coat from a transverse section of the seed corresponding to the corrugated region. × 68.

PLATE 2. DATURA ALBA NEES

FIG. 18. A group of isolated cells of the testa; *a-c*, cells from the corrugated region; *d-g*, cells from the region corresponding to the flat surface of the seed. × 68.

FIG. 19. A surface view of the cells of the testa, showing interlacing processes, *pr*. × 68.

20. A thin tangential section of the testa from the convoluted region of the seed coat, showing the striated and double character of the cell walls. × 68.

21. A cross section through the midrib; *ph*, phloëm; *cc*, crystal cell containing calcium oxalate crystal in rosette form; *cr*, sphenoidal microcrystal of calcium oxalate. × 68.

22. Surface view of the upper epidermis. × 200.

23. Surface view of the lower epidermis. × 200.

PLATE 3. DATURA ALBA NEES

24. Surface view of the upper epidermis cleared with a dilute solution of chloral hydrate, showing striation of the cuticle. × 285.

25. Surface view of the lower epidermis cleared with a dilute solution of chloral hydrate, showing striation of the cuticle. × 285.

26. Surface view of the outer epidermis of the calyx. × 200.

27. Surface view of the inner epidermis of the calyx. × 200.

28. Surface view of the inner epidermis of the corolla. × 200.

29. A glandular hair from the lower epidermis of the leaf. × 285.

30. A glandular hair from the corolla with shriveled terminal head and thick-walled basal cells. × 200.

31. A glandular hair from the corolla. × 200.

32. Group of calcium oxalate crystals; *a*, *f*, *g*, *h*, from the midrib; *b*, *c*, *d*, *e*, *g*, from the blade. × 285.

PLATE 4. DATURA FASTUOSA LINNÆUS

FIG. 33. A habit sketch of a portion of the plant, showing a flower with triple corolla. × ½.

34. A mature leaf. × ½.

35. A flower with double corolla. × ½.

36. The corolla split down one side; co_1, outer corolla which is free from the inner ones; co_2, second corolla from outside; co_3, innermost, or third corolla; *ap*, appendagelike structures found between the second and the third corollas. × ½.

37. A portion of the dorsal part of the third corolla and a portion of the ventral part of the second corolla, showing the five linear, appendagelike structures between them. × ½.

38. Two views of a stamen before dehiscing; *a*, dorsal view; *b*, ventral view. × ½.

39*a*. Pollen grains as they appear when mounted dry. × 200.

39*b*. Pollen grains when mounted in water. × 200.

40. A pistil with a portion of the style removed; *c*, basal portion of calyx; co_1, co_2, co_3, basal portions of the corolla; *ng*, nectary gland; *o*, ovary with flat processes; *s*, basal part of style; *st*, stigma. × 2.

41. Diagrammatic drawing of a transverse section from the upper part of an ovary. × 5.

42. Diagrammatic drawing of a transverse section from the lower part of an ovary. × 5.

FIG. 43. Inner corolla of an abnormally borne corolla, split down one side and spread, showing the five epipetalous stamens with filaments provided with appendages. × ½.

44. Stamens from the specimens illustrated in fig. 43, drawn natural size; *a*, normal; *b-f*, with winglike structure. × 1.

45. A fruit without spines, showing method of dehiscing. × ½.

PLATE 5. DATURA FASTUOSA LINNÆUS

FIG. 46. A fruit with few and short spines.

47. An abnormally borne flower, showing the middle part of the inner corolla tube bent and protruding at the side of the outer corolla.

48. Three stages of abnormally borne corolla.

49. The flower; *a*, abnormal flower split down one side, showing the normal anthers and the united filaments with appendages, or winglike structures; *b*, an abnormal flower, in which the filaments are not united.

50. The flower; *a*, an abnormally borne flower, compared with *b*, a normally borne flower.

PLATE 6. DATURA FASTUOSA LINNÆUS

FIG. 51. The seed; *a*, flat side of mature seed; *b*, dorsal side. × 2¼.

52. Diagrammatic drawing of a median longitudinal section of a seed, cut in the plane parallel to the flat surface; *sc*, seed coat; *e*, endosperm; *em*, embryo; *h*, hilum. × 4½.

53. Diagrammatic drawing of a transverse section of a seed, cut at right angles to the flat surface; *sc*, seed coat; *e*, endosperm, *ct*, cotyledons; *r*, radicle. × 4½.

54. A thin transverse section through the seed coat and endosperm; *t*, testa; *p*, parenchyma region; *op*, obliterated parenchyma region; *pe*, perisperm; *e*, endosperm. × 4½.

55. A highly magnified drawing of an endosperm cell; *a*, aleurone grain. × 285.

56. A small portion of the seed coat from a transverse section of the seed near the region of the flat surface. × 68.

57. A small portion of the seed coat from a transverse section of the seed corresponding to the flat surface. × 68.

58. A small portion of the seed coat from a transverse section of the seed corresponding to the corrugated region. × 68.

59. Surface view of the cells of the testa, showing the interlacing outgrowths from the cells. × 68.

60. A thin tangential section through the corrugated region of the seed coat, showing the striation and double character of the cell walls. × 68.

61. A group of isolated cells of the testa; *a-d*, cells from the corrugated region; *e-h*, cells from the region corresponding to the flat surface of the seed. × 68.

62. A cross section through the midrib; *ph*, phloëm; *cc*, crystal cell containing calcium oxalate crystals in rosette form; *cr*, calcium oxalate crystals in prismatic form; cr_s, sphenoidal microcrystals of calcium oxalate. × 68.

PLATE 7. DATURA FASTUOSA LINNÆUS

FIG. 63. Surface view of the upper epidermis of a leaf. × 200.
64. Surface view of the lower epidermis of a leaf. × 200.
65. Surface view of the upper epidermis of a leaf, cleared with a dilute solution of chloral hydrate, showing striation of the cuticle. × 285.
66. Surface view of a leaf with the epidermis cleared with a dilute solution of chloral hydrate, showing striation of the cuticle. × 285.
67. Surface view of the outer epidermis of calyx. × 200.
68. Surface view of the inner epidermis of calyx, showing aborted stomata or young stomata. × 200.
69. Surface view of the outer epidermis of the corolla. × 200.
70. A glandular hair from the calyx. × 285.
71. A glandular hair from the leaf. × 285.
72. A glandular hair from the corolla. × 200.
73. A glandular hair from the corolla. × 200.
74. Group of calcium oxalate crystals; *b-f*, from blade; *a*, *g-m*, from midrib. × 285.

5b
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PLATE 1.

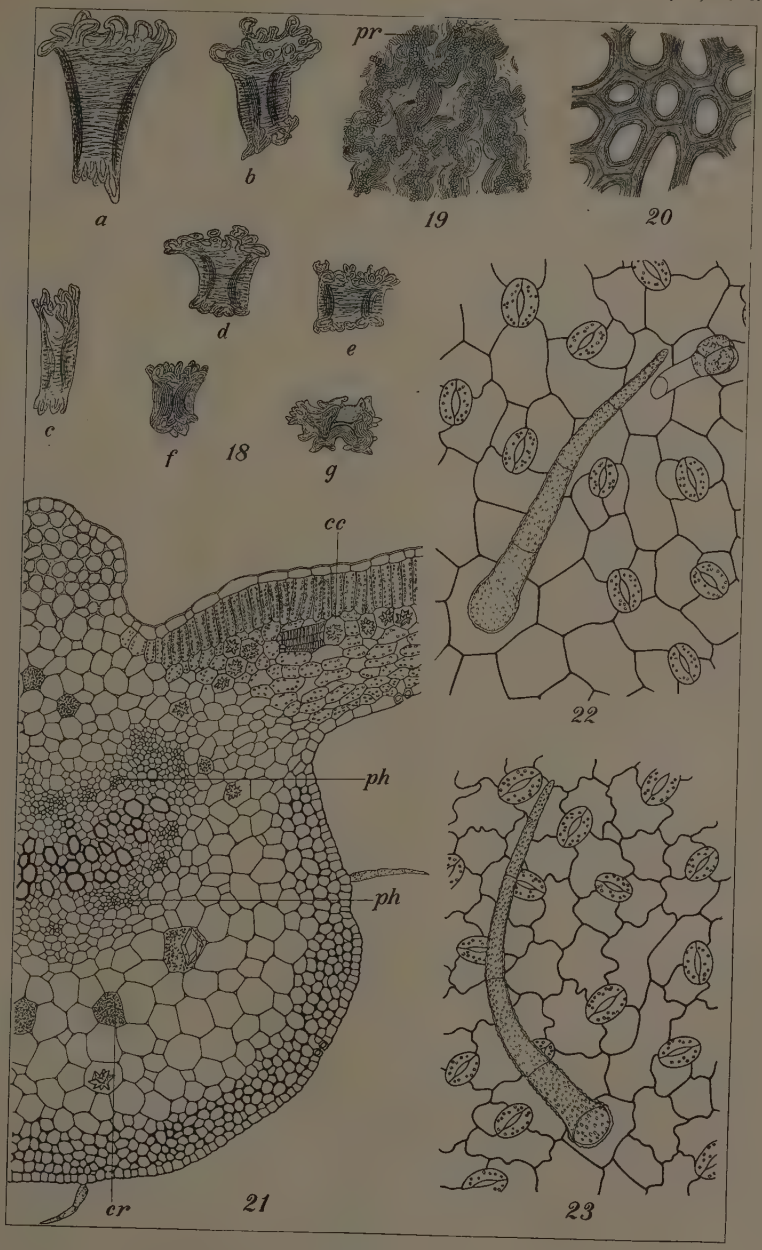

PLATE 2.

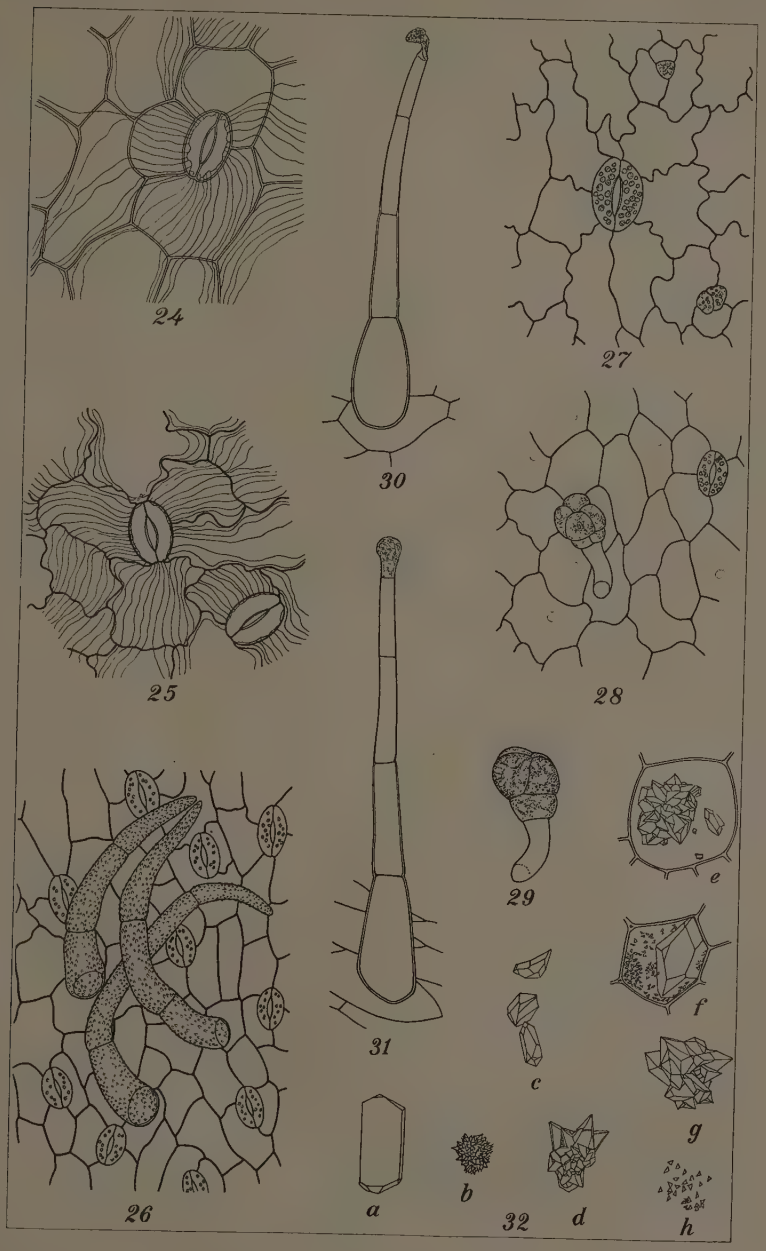

PLATE 3.

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PLATE 4.

PLATE 5.

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cr2
e
61
f
g
62

PLATE 6.

PLATE 7.

REDUCTION OF LINOLENIC AND LINOLIC BROMIDES AND REBROMINATION OF THE FREE ACIDS

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and

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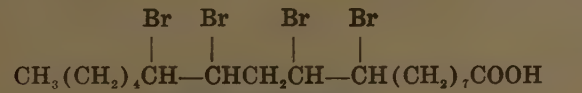
Professor of Chemistry, University of the Philippines

ONE TEXT FIGURE

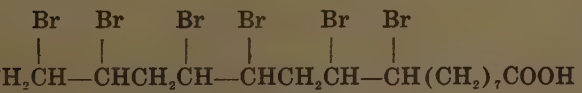
INTRODUCTION

The unsaturated glycerides of linolic and linolenic acids occur naturally in vegetable drying oils and are the principal substances that absorb oxygen from the air and cause the oil to dry. These glycerides and the corresponding unsaturated linolic and linolenic acids are therefore compounds of considerable commercial importance.

When linolic and linolenic acids are brominated they are converted into their bromo addition products; namely, linolic tetrabromide and linolenic hexabromide.



linolic tetrabromide



linolenic hexabromide

These bromination reactions may not, however, be as simple as the equations would seem to indicate.

Erdmann and Bedford [1] prepared linolenic hexabromide from linseed oil. When the hexabromide was reduced to the free linolenic acid and again brominated they obtained a mixture of the original crystallized hexabromide and some liquid bromide.

[1] Ber. Deut. Chem. Gesell. 42 (1909) 1328.

Takahashi [2] carried out some elaborate bromination experiments on the linolic acid obtained from soy-bean oil. He first prepared linolic tetrabromide (melting point, 114° C.) from soy-bean oil. This tetrabromide was reduced to the free linolic acid and again brominated. He obtained three types of bromo derivatives which he designated as follows:

1. Alpha linolic tetrabromide; crystals insoluble in petroleum ether; melting point, 113.5 to 114° C.
2. Beta linolic tetrabromide; crystals soluble in petroleum ether; melting point, 59 to 60° C.
3. Gamma linolic tetrabromide; liquid soluble in petroleum ether.

When each of these types was again reduced to the free linolic acid and brominated, each type gave the same three varieties of bromo derivatives. Each type, however, always gave more of its own kind.

The experiments of Erdmann and Bedford and the work of Takahashi indicate that either the elimination of bromine or the readdition of it gave molecular rearrangements which produced isomeric bromides.

Philippine lumbang oil is a drying oil used in making paints, varnishes, and similar products.[3] It consists almost entirely of glycerides of the unsaturated acids, linolenic, linolic, and oleic.[4] A recent investigation[5] showed that, when the mixed acids of lumbang oil are brominated, linolenic hexabromide, four linolic tetrabromides (alpha, beta, delta, and gamma), and oleic dibromide are obtained. Gamma linolic tetrabromide and oleic dibromide are oils, whereas the other bromides are crystalline compounds.

The present investigation was undertaken to ascertain if the linolenic and linolic acids (from lumbang oil), when brominated, reduced, and again brominated, would give the same isomeric bromo derivatives as do the corresponding linolenic acid from linseed oil and the linolic acid from soy-bean oil. We also endeavored to learn if any molecular rearrangement occurs with lumbang compounds, and if such rearrangement is due to the removal of bromine from the bromo derivative or to the rebromination of the free acid.

Our results seem to show that the lumbang linolenic compounds have the same general characteristics as do the linseed

[2] Journ. Tokyo Chem. Soc. 40 (1919) 233.
[3] West, A. P., and F. L. Smith, Bull. P. I. Bur. Forestry 24 (1923).
[4] West, A. P., and Z. Montes, Philip. Journ. Sci. 18 (1921) 619.
[5] Santiago, S., and A. P. West, Philip. Journ. Sci. 32 (1917) 41–52.

linolenic compounds. The lumbang linolic compounds, however, had a chemical behavior quite different from that of the soybean linolic compounds. Our experiments also indicate that molecular rearrangements occur with lumbang compounds. The rearrangement appears to take place during the removal of bromine from the bromo derivative and not during the bromination of the free acid.

EXPERIMENTAL PROCEDURE

Preparation of materials.—The linolenic hexabromide and linolic tetrabromides used in these experiments were prepared in accordance with the procedure adopted by Santiago and West [6] in a recent investigation of lumbang compounds. The method of preparation was, in general, as follows: The lumbang oil was saponified with aldehyde-free alcoholic potassium hydroxide. The mixed potassium soaps thus obtained were converted in neutral solution into zinc soaps. The precipitated zinc soaps were removed by filtering and washed thoroughly with water to eliminate the lumbang odoriferous oil. The mixed zinc soaps were then treated with dilute sulphuric acid in an atmosphere of carbon dioxide and converted into the mixed acids.

Linolenic hexabromide.—The mixed acids were brominated in ether solution according to the procedure used by Imperial and West [7] in preparing linolenic hexabromide. The ether solution of mixed acids was stirred mechanically by means of a hot-air motor and brominated at —10° C. The insoluble linolenic hexabromide was removed by filtering. After crystallizing from ethyl acetate and benzene the melting point of the hexabromide was 179.5 to 180.5° C. The bromine content was 63.02 per cent. Theory requires 63.32 per cent bromine.

Linolic tetrabromides.—The ethereal filtrate from the hexabromide was treated with sodium thiosulphate solution to remove the bromine, dehydrated with sodium sulphate, and distilled to eliminate the ether. The residue was treated with cold petroleum ether which precipitated a mixture of linolic tetrabromides. The crude solid tetrabromides were separated from the oily (gamma) tetrabromide and the oily oleic dibromide by filtering. The crude crystalline tetrabromides were washed with petroleum ether, after which they were crystallized from ethyl alcohol. Two crops of impure alpha linolic tetrabromide (melting point 110 to 113° C.) were obtained. The crude alpha tetrabromide

[6] Philip. Journ. Sci. 32 (1927) 41–52.
[7] Philip. Journ. Sci. 31 (1926) 441–449.

was washed again with petroleum ether and crystallized once from gasoline and several times from ethyl alcohol. After this further purification the melting point was 112.3 to 114.3° C. The bromine content was 53.73 per cent. Theory requires 53.33 per cent bromine.

When the filtrate from the second crop of the alpha compound was concentrated, by distilling off about a third of the alcohol, a red oily layer separated out at the bottom of the alcoholic solution. The red oil was separated from the supernatant alcoholic solution of the alpha compound. When shaken with a small quantity of cold ethyl alcohol a considerable portion of it gradually crystallized and was converted into silky crystals.

That portion of the red oil which did not crystallize gave a bromine content of 53.69 per cent and was thus shown by analysis to be a liquid linolic tetrabromide (gamma).

The silky crystals obtained from a portion of the red oil were crystallized from ethyl alcohol. The melting point was 59.6 to 60.6° C. The bromine content was 53.44 per cent. The silky crystals, as shown by Santiago and West, are a mixture of two substances—beta linolic tetrabromide and delta linolic tetrabromide.

The following bromo derivatives were thus prepared from lumbang oil and used as materials for this investigation:

Bromo derivatives.	Melting point. °C.
Linolenic hexabromide	179.5 to 180.5
Linolic tetrabromides:	
Alpha	112.3 to 114.3
Mixture beta and delta	59.6 to 60.6
Gamma	Liquid.

Reduction of linolenic hexabromide.—Linolenic hexabromide was reduced to the corresponding free linolenic acid according to the general procedure used by Erdmann and Bedford.[8] The bromide was reduced with zinc filings in alcoholic solution. A part of the bromide was thus converted into an ester and the remainder into the zinc salt. Both the ester and the zinc salt were then changed to the free linolenic acid.

In carrying out these experiments 6 grams of hexabromide were treated with 250 cubic centimeters of alcohol and 15 grams of zinc filings. Three drops of alcoholic platinum chloride solution were then added, in accordance with the suggestion of

[8] Ber. Deut. Chem. Gesell. 42 (1909) 1328.

Matthes and Boltze.[9] The mixture was heated on a water bath (reflux) until the reduction was complete, which required about twenty-four hours. The zinc was removed by filtering through a covered funnel in an atmosphere of carbon dioxide, using an apparatus arranged according to the diagram (fig. 1). A half-

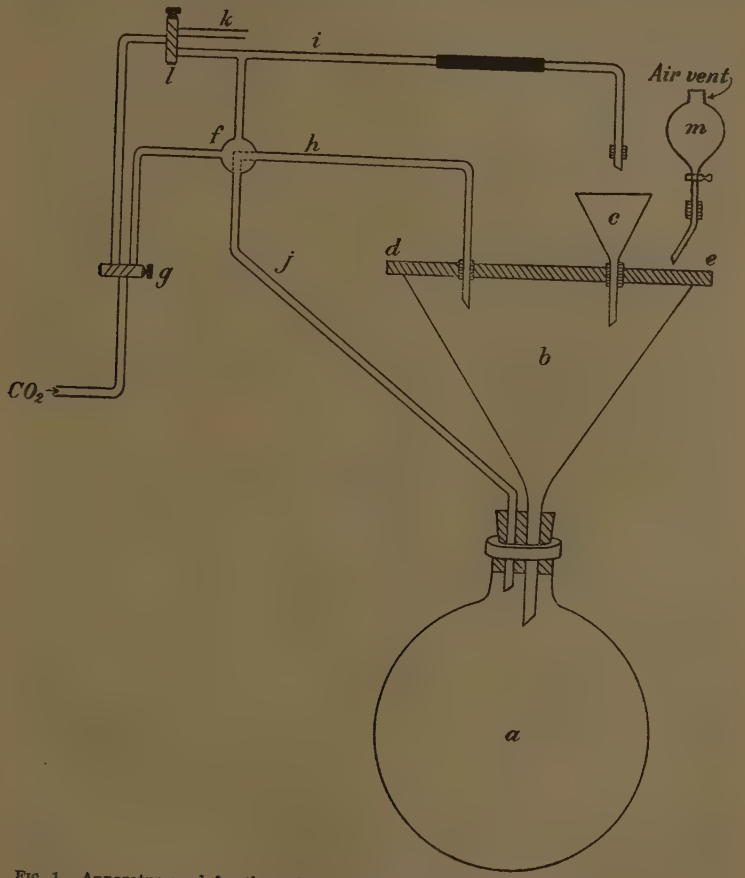


FIG. 1. Apparatus used for the reduction of bromo derivatives of unsaturated acids.

liter flask *a* was connected to a funnel *b*, containing filter paper. The funnel was covered with a glass plate *de*, containing two holes. Through one hole passed a funnel *c*. The tubes *h* and *j* were connected to the three-way stopcock *f*, which allowed the

[9] Arch. d. Pharm. 250 (1912) 223.

carbon dioxide to flow into flask *a* and funnel *b*. The two-way stopcock *g* allowed the excess of carbon dioxide to escape into the air through the tube *k* when the pressure became too great, and also through the tube *i* when it was desirable to obtain a closed circuit in the apparatus through the stopcock *f*. By allowing carbon dioxide to enter the apparatus through the circuit *g*, *f*, *j*, the air was replaced by the carbon dioxide. The stopcock *f* was then adjusted so that the carbon dioxide flowed according to the circuit *a*, *j*, *f*, *h*, *b*.

The mixture of reduced bromide and zinc was poured through the funnel *c*, and filtered into the flask *a*, through the paper in the funnel *b*. Immediately after all the mixture was poured through the funnel *c*, the funnel *c* was removed and replaced by the separating funnel *m*. Carbon dioxide was then admitted through the circuit *g*, *l*, *i*, *m*. When all the mixture had filtered into flask *a*, the flask *a* was removed and connected to a condenser, and the mixture distilled in a current of carbon dioxide to eliminate the alcohol. During the distillation the glass plate *de* was removed and the filter paper containing the zinc taken out of the funnel *b*. The glass plate *de* was again placed over the funnel *b*.

When all the alcohol had been distilled out of the mixture in flask *a*, the flask was again connected to the funnel *b*. The carbon dioxide circuit was still the same as in the filtering operation. One hundred fifty cubic centimeters of hot water were then poured into the separating funnel *m*, at the top of the apparatus, and allowed to flow into the flask *a*, containing the mixture of ester and zinc salt which were precipitated. A solution of hot sulphuric acid (1 : 1) was then poured through the separating funnel *m*, into the flask *a*, which was shaken gently. The acid was added until the mixture in the flask had a decided acid reaction, as shown by the indicator methyl orange, previously added. After standing a short time the zinc salt was completely decomposed and the solution had a clear appearance.

A bath of ice water was then placed under flask *a*, and raised until the flask was completely immersed in the water. When the mixture in flask *a* had cooled to room temperature, about 50 cubic centimeters of ether were poured through the separating funnel *m*, at the top of the apparatus. The flask *a* was then disconnected and a large separating funnel connected to the apparatus in the position just previously occupied by flask *a*. The contents of flask *a* were then poured into a second separating funnel, previously filled with carbon dioxide, and the lower acid

layer was drawn off into a third separating funnel. The ether layer was then poured through the small separating funnel *m*, at the top of the apparatus, into the first large separating funnel at the bottom of the apparatus. The acid solution in the third separating funnel was then extracted three times with ether and the ether extracts were poured through the apparatus into the large separating funnel containing the first ether extract. Cold boiled distilled water was then poured through the top of the apparatus into the ether extract in the separating funnel at the bottom of the apparatus. The funnel was given a whirling motion in order to wash the ether extract, after which the aqueous solution was separated. The ether solution was thus washed several times with distilled water until free of acid. The ether solution was then drawn off into a half-liter balloon flask and distilled on a water bath (60° C.) in a current of carbon dioxide until the ether extract was reduced to a volume of about 50 cubic centimeters. The stopper, through which the carbon dioxide inlet tube passed, was then raised slightly and about 200 cubic centimeters of aldehyde-free alcohol were added to the ether extract. An alcoholic solution of potassium hydroxide, containing about one gram of potassium hydroxide, was poured into a separating funnel. The separating funnel was inserted into the balloon flask until the lower end was slightly below the surface of the ether extract. The potassium hydroxide solution was then allowed to flow into the ether extract. The mixture was then heated on a water bath (reflux) until the ester was completely saponified, which required about three and a half hours. The alcohol and ether were then removed by distilling in a current of carbon dioxide. The free organic acid was liberated with sulphuric acid and extracted with ether, as in the previous extraction. The combined ether extracts were dehydrated with sodium sulphate and filtered in an atmosphere of carbon dioxide into a liter flask.

Rebromination of linolenic acid.—The ether extract was diluted with ether to a volume of about 600 cubic centimeters and brominated according to the general procedure used by Imperial and West [10] in preparing linolenic hexabromide. The ethereal solution was stirred mechanically by means of a hot-air motor and cooled to a temperature of —10° C. Carbon dioxide was passed into the flask above the surface of the liquid; the solution, in this atmosphere of carbon dioxide, was then treated

[10] Philip. Journ. Sci. 31 (1926) 441–449.

with 3.5 cubic centimeters of bromine. After bromination the crystallized hexabromide was removed by filtering. The ethereal filtrate from the hexabromide was treated with sodium thiosulphate solution to remove the excess bromine, after which it was dehydrated with sodium sulphate and the ether eliminated by distilling. The residue was a very light yellow oil which gradually turned somewhat dark. About 30 per cent of the material was lost in manipulation. Approximately 46.8 per cent of the reaction products consisted of crystallized hexabromide (melting point 180 to 182° C.) which gave a bromine content of 63.04 per cent. The liquid hexabromide, which analyzed 63.28 per cent bromine, constituted 53.2 per cent of the reaction products. The theoretical bromine content of linolenic hexabromide is 63.32 per cent.

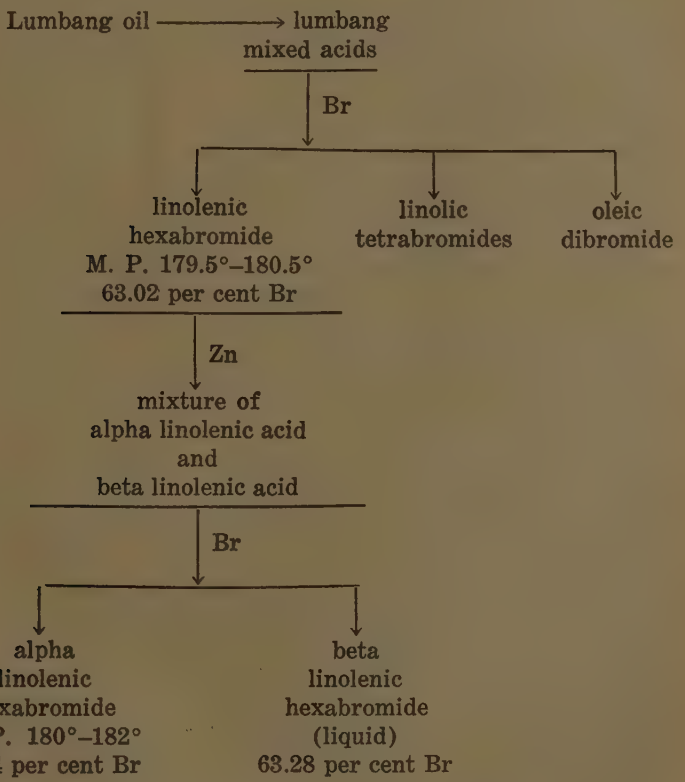
Results with linolenic compounds.—Our results with lumbang linolenic acid are quite similar to the results obtained by Erdmann and Bedford [11] with linseed linolenic acid. They found, when the crystallized linolenic hexabromide from linseed oil was reduced and the reaction product brominated, that a crystallized hexabromide and also a liquid bromide were obtained.

When the mixed acids of lumbang oil are brominated directly, no liquid linolenic hexabromide is obtained, but only the crystallized hexabromide. Evidence favoring this view is the fact that the liquid linolic tetrabromide obtained from the filtrate of the crystallized linolenic hexabromide was found, as will be shown later, to contain a hexabromide which on reduction and rebromination gave the same proportion of crystalline and liquid hexabromide as the original crystalline hexabromide gave when reduced and brominated. These results indicate that the hexabromide, which is contained in the liquid tetrabromide, is the ordinary crystalline hexabromide obtained only by brominating the one linolenic acid present in the lumbang mixed acids. The mixed acids of lumbang oil appear to contain only one linolenic acid, and when this acid is brominated only one hexabromide is obtained. When this crystallized hexabromide is reduced with zinc a molecular rearrangement seems to occur and two linolenic acids are obtained; namely, alpha and beta. Bromination of these mixed linolenic acids gives the crystallized alpha linolenic hexabromide and the liquid beta linolenic hexabromide.

[11] Ber. Deut. Chem. Gesell. 42 (1909) 1328.

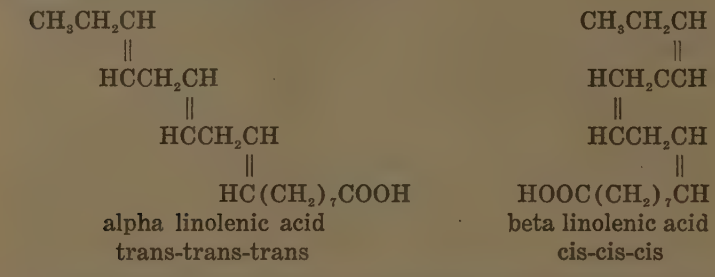
Our results seem to show that the molecular rearrangement occurs during the reduction of the bromide and not during the bromination of the free acid because, when the mixed lumbang-free acids are first brominated, only one linolenic hexabromide is obtained and that is the crystalline hexabromide. If isomeric linolenic hexabromides were obtained by brominating directly the mixed acids of lumbang oil, this would indicate that, possibly, a molecular rearrangement had occurred due to the bromination process, but such isomers are not obtained.

The results we obtained with lumbang linolenic compounds may be outlined as follows:


Lumbang oil
lumbang mixed acids
Br
linolenic hexabromide M. P. 179.5°–180.5° 63.02 per cent Br
linolic tetrabromides
oleic dibromide
Zn
mixture of alpha linolenic acid and beta linolenic acid
Br
alpha linolenic hexabromide M. P. 180°–182° 63.04 per cent Br
beta linolenic hexabromide (liquid) 63.28 per cent Br

As shown by the above outline the crystallized linolenic hexabromide, when reduced, yields two linolenic acids; namely,

alpha and beta. These acids may, perhaps, be regarded as geometrical isomers. With such substances the isomer having the highest melting point is usually the trans form.[12] Since the alpha acid gives the crystalline hexabromide, while the beta acid yields the liquid hexabromide, the alpha acid may be a trans-trans-trans form and the beta acid the cis-cis-cis form, as represented by the following formulas:



alpha linolenic acid
trans-trans-trans

beta linolenic acid
cis-cis-cis

Alpha linolic tetrabromide.—Alpha linolic tetrabromide (melting point 112.3 to 114.3° C.) was prepared from lumbang oil. It was then reduced to the free acid which was again brominated in accordance with the methods previously described for linolenic hexabromide. In these experiments 10 grams of the tetrabromide were treated with 250 cubic centimeters of alcohol and 25 grams of zinc filings. The mixture was heated on a water bath (reflux) for three and a half hours. The free acid was brominated by treating it with 1.8 cubic centimeters of bromine. About 34 per cent of the material was lost in manipulation. Approximately 48 per cent of the reaction product was crystallized alpha linolic tetrabromide (melting point 112.3 to 114.3° C.) which analyzed 53.16 per cent bromine. About 48 per cent was liquid tetrabromide (gamma) which analyzed 53.88 per cent bromine. The theoretical bromine content of linolic tetrabromide is 53.33 per cent. There was also obtained about 3 per cent of crystallized tetrabromide (melting point 109 to 112° C.) which was probably an impure form of the alpha compound. Beta and delta linolic tetrabromides were not obtained as reaction products.

Similar experiments carried out by Takahashi with the alpha linolic tetrabromide (melting point 114° C.) from soy-bean oil

[12] Stewart, A. W., Stereochemistry (1907) 175 and 177; Michael, A., Journ. für Prak. Chem. 52 (1895) 349.

showed that the alpha tetrabromide and also some beta (melting point 59 to 60° C.) and liquid gamma tetrabromide were obtained from the alpha compound.

Beta and delta linolic tetrabromides (silky crystals).—The silky crystals (melting point 59.6 to 60.6° C.), which consisted of a mixture of beta and delta tetrabromides, were reduced to the free linolic acids which were again brominated in accordance with the procedure used for the reduction and bromination of the alpha compound. About 38 per cent of the materials was lost in manipulation and the yield of reaction products was about 62 per cent. Approximately 30 per cent of the reaction products was crystallized alpha linolic tetrabromide (melting point 112.3 to 114.3° C.) which gave a bromine content of 53.05 per cent. The amount of liquid tetrabromide (gamma) contained in the reaction products was about 66 per cent. The gamma compound analyzed 53.37 per cent bromine. There was also obtained about 3.5 per cent of crystallized bromide (melting point 109 to 112° C.). This was probably an impure form of the alpha tetrabromide. Beta and delta linolic tetrabromides were not obtained as reaction products. This indicated that the tetrabromides were reduced completely to the free alpha and gamma linolic acids.

Beta linolic tetrabromide from soy-bean oil, when reduced and brominated by Takahashi, gave a mixture of crystallized alpha and beta tetrabromides and also some liquid gamma tetrabromide.

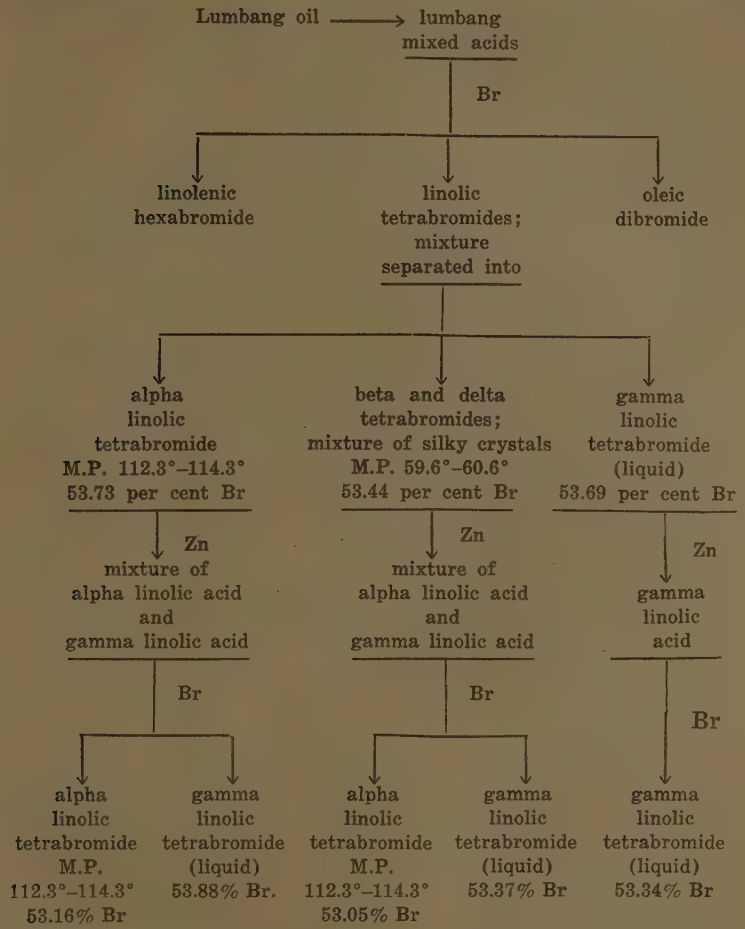
Gamma linolic tetrabromide.—The liquid gamma linolic tetrabromide was reduced and brominated under the same conditions as were the other tetrabromides. The reaction product consisted of 94.7 per cent of the original liquid gamma tetrabromide (bromine content, 53.34 per cent) and 5.3 per cent of linolenic hexabromides. Alpha, beta, and delta linolic tetrabromides were not obtained as reaction products. These hexabromide impurities consisted of 2.8 per cent of liquid hexabromide (bromine content, 62.82 per cent) and 2.5 per cent of crystalline hexabromide (melting point 180 to 184° C.). These hexabromide figures, when calculated to a basis of 100 per cent, gave 46.8 per cent crystalline hexabromide and 53.2 per cent liquid hexabromide. These figures are the same as those previously obtained by reduction and bromination of the crystalline hexabromide. The presence of these hexabromides in the liquid

gamma tetrabromide was probably due to the fact that the crystalline hexabromide, which is prepared by brominating directly the mixed acids of lumbang oil, is slightly soluble in alcohol, ether, and petroleum ether. In separating out the various linolic tetrabromide preparations the liquid gamma tetrabromide, which remains as a residue, is likely to contain substances, such as hexabromides, which may be present as impurities. If the gamma tetrabromide contains some crystalline hexabromide as impurity then when the impure gamma compound is reduced and brominated the crystalline hexabromide present as impurity will act as a pure crystalline hexabromide acts when reduced and brominated, and yield a mixture of crystalline and liquid hexabromides in the same proportions as are obtained from the crystalline hexabromide. As these results were actually obtained, the data indicate that when the mixed acids of lumbang oil are brominated the mixture of bromo derivatives contains only one hexabromide which is the crystalline linolenic hexabromide.

Results with linolic compounds.—Our experiments with lumbang linolic compounds gave results quite different from those obtained by Takahashi with the corresponding compounds made from soy-bean oil. Takahashi found that, when alpha linolic tetrabromide is reduced and the reaction product brominated, three types of bromides are obtained—alpha, beta, and gamma. Each type when again reduced and brominated gave the same three varieties (alpha, beta, and gamma) of bromo derivatives. It appears that Takahashi did not obtain from soy-bean oil a fourth variety of linolic tetrabromides corresponding to the delta tetrabromide which can be prepared from lumbang oil. Possibly his beta compound was really a mixture of beta and delta compounds and resembled our silky crystals which were a mixture of these substances.

In our experiments the alpha compound when reduced and brominated gave no beta or delta tetrabromides, but only the alpha and gamma tetrabromides. The beta and delta tetrabromides, reduced and brominated, also gave only the alpha and gamma tetrabromides. The gamma compound, treated in a similar manner, was converted back again into the same gamma compound.

Our results with lumbang linolic compounds may be outlined as follows:

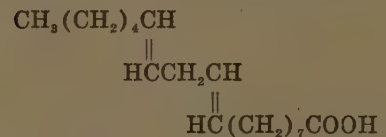

Lumbang oil
lumbang mixed acids
Br
linolenic hexabromide
linolic tetrabromides; mixture separated into
oleic dibromide
alpha linolic tetrabromide M.P. 112.3°–114.3° 53.73 per cent Br
beta and delta tetrabromides; mixture of silky crystals M.P. 59.6°–60.6° 53.44 per cent Br
gamma linolic tetrabromide (liquid) 53.69 per cent Br
Zn
mixture of alpha linolic acid and gamma linolic acid
Zn
mixture of alpha linolic acid and gamma linolic acid
Zn
gamma linolic acid
Br
Br
Br
alpha linolic tetrabromide M.P. 112.3°–114.3° 53.16% Br
gamma linolic tetrabromide (liquid) 53.88% Br.
alpha linolic tetrabromide M.P. 112.3°–114.3° 53.05% Br
gamma linolic tetrabromide (liquid) 53.37% Br
gamma linolic tetrabromide (liquid) 53.34% Br

The beta and delta linolic tetrabromides are not obtained by reducing any tetrabromides and again brominating the resulting free linolic acids. The beta and delta linolic tetrabromides are prepared only by brominating directly the mixed acids of lum-

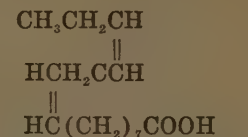
bang oil. It would thus appear that the mixed acids of lumbang oil contain in addition to the alpha and gamma linolic acids also two other linolic acids; namely, beta and delta. When brominated the beta acid yields the beta tetrabromide, while the delta acid gives the delta tetrabromide. Reduction of the beta and delta tetrabromides appears to give a molecular rearrangement and these substances are converted into a mixture of alpha and gamma linolic acids which, when again brominated, yield the corresponding alpha and gamma tetrabromides. As in the case of linolenic compounds, the molecular rearrangement appears to occur only during the reduction of the bromides and not during the bromination of the free acids.

Data obtained by Santiago and West [13] in a recent investigation of lumbang oil indicated that, by brominating directly the mixed acids of lumbang, there were obtained a crystalline linolenic hexabromide, four linolic tetrabromides, and one oleic dibromide. These various bromides appeared to be derivatives of the corresponding acids contained as glycerides in the oil. The results of the present investigation seem to confirm the data obtained in this previous research.

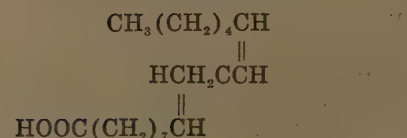
The lumbang mixed acids appear to contain four linolic acids. These acids may, perhaps, be regarded as geometrical isomers. If they are named in accordance with the melting point of the tetrabromide derivative then these acids may perhaps be represented by the following formulas:



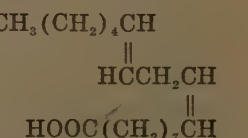
alpha linolic acid
trans-trans



gamma linolic acid
cis-cis



beta linolic acid
trans-cis



delta linolic acid
cis-trans

[13] Philip. Journ. Sci. 32 (1927) 41–52.

SUMMARY

An apparatus and procedure have been described for the satisfactory reduction of bromo derivatives of long-chain unsaturated acids.

Lumbang linolenic compounds have the same general characteristics as do the linseed linolenic compounds. When the lumbang mixed acids are brominated directly, only one linolenic hexabromide (melting point 179.5 to 180.5° C.) is obtained. This indicates that, when the glycerides of lumbang oil are converted to acids, these mixed acids contain only one linolenic acid.

When lumbang linolenic hexabromide is reduced and the reaction product brominated two linolenic hexabromides are obtained—crystalline linolenic hexabromide (melting point 180 to 182° C.) and liquid hexabromide. These results seem to indicate that a molecular rearrangement occurs during the reduction of the hexabromide and not during the bromination of the free acid, because bromination of the mixed lumbang acids gives only the crystalline linolenic hexabromide.

Toward reduction and rebromination the behavior of lumbang linolic compounds is somewhat different from that of the soybean linolic compounds. When alpha linolic tetrabromide from soy-bean oil is reduced and the reaction product (free acid) again brominated, three types of bromides are obtained; namely, alpha, beta, and gamma. When the lumbang alpha linolic tetrabromide is reduced and rebrominated the alpha and gamma linolic tetrabromides are the only products obtained. Reduction and rebromination of the lumbang beta and delta tetrabromides also give a mixture of alpha and gamma tetrabromides. The gamma compound treated in a similar manner gives only the same gamma compound.

Beta and delta linolic tetrabromides are prepared only by brominating directly the mixed acids of lumbang oil. Reduction of the beta and delta tetrabromides appears to give a molecular rearrangement and these substances are converted into a mixture of alpha and gamma linolic acids which, when brominated, yield the corresponding alpha and gamma tetrabromides. As in the case of linolenic compounds, the molecular rearrangement appears to take place only during the reduction of the bromides, and not during the bromination of the free acids.

Data obtained in a recent investigation indicated that by brominating directly the mixed acids of lumbang oil a crystalline

linolenic hexabromide, four linolic tetrabromides, and one oleic dibromide are obtained. These various bromides appeared to be derivatives of the corresponding acids contained as glycerides in the oil. The results of the present investigation seem to confirm the data obtained in this previous research.

The lumbang mixed acids appear to contain four linolic acids. These acids may, perhaps, be regarded as geometrical isomers and distinguished according to the melting point of their bromo derivatives as follows:

Alpha linolic acid (trans-trans).
Beta linolic acid (trans-cis).
Delta linolic acid (cis-trans).
Gamma linolic acid (cis-cis).

ILLUSTRATION

TEXT FIGURE

FIG. 1. Apparatus used for the reduction of bromo derivatives of unsaturated acids.

A MODIFIED COMBUSTION METHOD FOR THE DETERMINATION OF BROMINE IN ORGANIC COMPOUNDS

By F. L. Smith, 2d

Chief Chemist, Quartermaster Corps, United States Army, Manila

TWO TEXT FIGURES

The Carius method is the usual standard method employed for determining halogens in organic compounds. Although the Carius method usually gives good results it is rather slow and laborious. Several methods, quicker and less troublesome than the Carius, have been suggested. These shorter methods do not always give really accurate results with all classes of halogen compounds. Reliable results may often be obtained with chlorine compounds, but not with bromine compounds.

In this paper is described a modification of the combustion method. This modification applies particularly to the determination of bromine in organic compounds and consists, essentially, in heating the substance and oxidizing it in a current of oxygen. The resulting gases are passed through a heated tube containing a platinum contact, a layer of asbestos, and another platinum contact. The gases are then passed into an absorption solution containing sodium carbonate, to which a small quantity of sodium sulphite has been added. When the combustion is finished and the substance is entirely decomposed, the absorption solution is heated with a small quantity of hydrogen peroxide to oxidize the sulphite to sulphate. The solution is then acidified with nitric acid and treated with an excess of standard silver nitrate (0.1 *N*). The mixture is filtered with the aid of suction. The excess silver nitrate is then titrated with a tenth normal solution of thiocyanate, using ferric alum as an indicator.

The results obtained in this investigation indicate that the bromine content of ring compounds as well as of long-chain compounds may be determined fairly accurately by this modified combustion method.

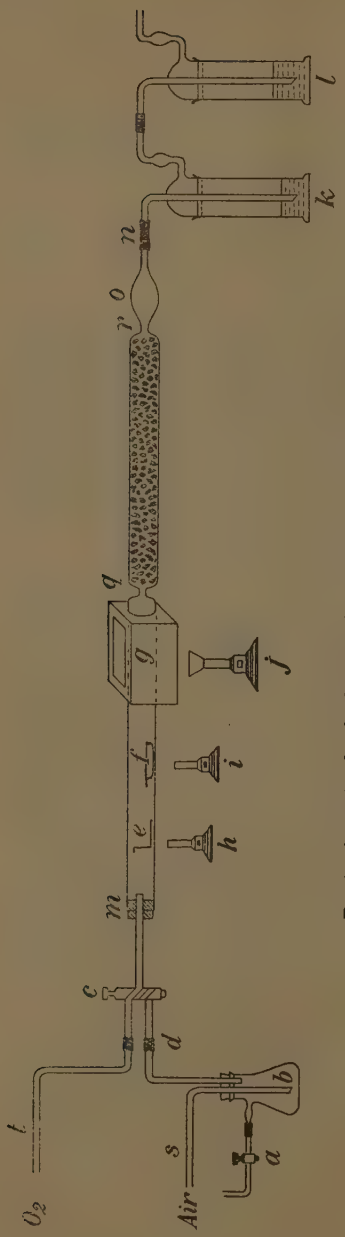


FIG. 1. Apparatus for the determination of bromine in organic compounds.

EXPERIMENTAL PROCEDURE

Apparatus.—The apparatus used for this method of bromine analysis was arranged according to the diagram given in fig. 1. A pyrex glass combustion tube *mn* (88 centimeters in length and 2.5 centimeters in diameter) was divided into two parts, *mq* and *qn*, by heating in a flame and making a constriction at the point *q* large enough to admit glass beads of the usual size. The tube was then heated near the absorption end *n*, and drawn out into the trap *o*. The constriction at *r* was made sufficiently small so that no glass beads could pass through into the trap *o*. This arrangement of the combustion tube was similar to that used by Pregl and Fyleman.[1] The lengths of the various parts of the tube were as follows: The length *mq* was 36 centimeters; *qr*, 33; and *rn*, 14. The absorption end *n* was drawn out somewhat so that it could be inserted into the exit end of a Drechsel wash bottle somewhat like the fit of a ground-glass stopper.

The absorption section *qr* of the tube was filled with glass beads. These were saturated with sodium carbonate solution, according to a procedure

[1] Quantitative Organic Micro Analysis (1924) 104.

to be described later. The wash bottles *k* and *l* contained a solution of sodium carbonate and sodium sulphite.

A portion, *g*, of the tube, about 20 centimeters from the combustion end *m*, was inclosed in an asbestos box.[2] The inside dimensions of the box were 13 centimeters long, 7.5 centimeters wide, and 8 centimeters high. The bottom of the asbestos box was perforated with a large hole, so that the combustion tube which passed through the box could be heated easily by the flame from a Terril fishtail burner. The hole in the bottom of the box was 11 centimeters long and 4 centimeters wide. There was also an opening in the top of the box, 10.5 centimeters long and 3.5 centimeters wide; it was covered with an asbestos lid. That portion of the tube inclosed in the asbestos box was wrapped with copper gauze so that when the tube was heated the heat would be somewhat evenly distributed over the entire surface of the tube.

The portion *g* of the combustion tube inside the asbestos box contained a round cylindrical basket made of platinum gauze. A special diagram of this section of the combustion tube is given in fig. 2, where *z* represents the platinum basket and *x* and *y* are platinum contacts. The platinum contacts were made of platinum foil and shaped somewhat like the letter W, with the ends bent over. The width was slightly less than the diameter of the combustion tube.

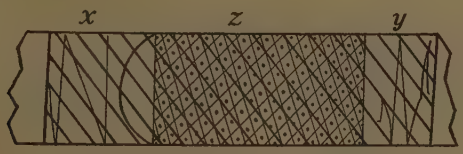


FIG. 2. Section of tube in asbestos box.

The length of the cylindrical basket was 7 centimeters and the diameter slightly smaller than the bore of the combustion tube. The basket was laced and bound with platinum wire and had a platinum wire handle so that it could be removed easily from the tube. The basket contained asbestos previously ignited. The asbestos sufficiently retarded the passage of volatile substances for them to be cracked and oxidized com-

[2] Meulen, H. Ter., Recueil Des Travaux Chimiques des Pays-Bas 43 (1924) 643; Smith, F. L., and A. P. West, Philip. Journ. Sci. 31 (1926) 265.

pletely.[3] This was necessary, particularly with substances that sublimed or distilled through the tube.

The porcelain boat *f* contained the substance to be analyzed.

The platinum foil *e*, 3.4 centimeters in length, was bent in the middle to the shape of the letter L. This preceded the boat and served as an oxygen baffle and preheater. Should the sample explode and send volatile products back toward the cool end *m* of the combustion tube, the hot preheater *e* would tend to send the vapors back to the hot part *g* of the tube containing the platinum basket. The preheater also tends to make the combustion complete by dispersing the entering oxygen gas.

The tube *t* served to admit oxygen to the apparatus through the two-way stopcock *c*, while the tube *s* admitted air. The flask *b* was an attachment to adjust or equalize the pressure.

Reagents.—All reagents used in this work were especially purified and tested for halogens. All solutions used were free from suspended particles. The distilled water used was redistilled until tests showed complete absence of halogens. The saturated solution of sodium carbonate free of halogens was prepared from sodium bicarbonate and made exactly according to the directions given by Pregl and Fyleman.[4] The sodium bisulphite solution free of halogens was prepared by treating sodium carbonate solution with sulphur dioxide according to the procedure given by Pregl and Fyleman.[5] The nitric acid free of halogens [6] was prepared by distilling the acid over silver nitrate in a current of carbon dioxide. The acid was then boiled until free of oxide fumes and water white in color. The iron alum indicator, tenth normal silver nitrate, and tenth normal thiocyanate solutions were all made according to procedures given by Sutton.[7] The hydrogen peroxide used was the best grade of Merks. The asbestos was the usual chemically pure ignited asbestos. It was washed thoroughly with nitric acid and distilled water until free of halogens and again ignited. The oxygen employed in these combustion experiments was electrolytic oxygen manufactured by the Philippine Acetylene Company. It

[3] Smith, F. L., and A. P. West, Philip. Journ. Sci. 31 (1926) 265.

[4] Quantitative Organic Micro Analysis (1924) 110.

[5] Op. cit. 111.

[6] Sutton, S., Volumetric Analysis, 2d ed. (1924) 152; Pregl, F., and E. Fyleman, Quantitative Organic Micro Analysis (1924) 110.

[7] Volumetric Analysis, 2d ed. (1924) 150, 151.

was purified by passing through a Drechsel wash bottle containing concentrated sulphuric acid and through three cylinders containing soda lime.

Analysis.—In carrying out this method of bromine analysis the apparatus was arranged in accordance with the diagram given in fig. 1. The apparatus was then taken apart temporarily and 1.5 cubic centimeters of saturated sodium carbonate solution were poured into the Drechsel wash bottle *l*, and 2 cubic centimeters of the same solution were poured into the wash bottle *k*. Three drops of sulphite solution were poured into each of the Drechsel wash bottles *l* and *k*. Distilled water (about 40 cubic centimeters) was then added to each wash bottle until the surface of the solution in the bottle was about 3 centimeters above the end of the inlet tube.

The combustion tube *mn* was held in a vertical position with the part *qn* below and the part *mq* above. The interior tube of a Liebig condenser was then inserted into the upper end *mq* of the combustion tube and lowered down to the constriction *q*. The lower end *n* of the combustion tube was closed by holding a finger over the outlet. Saturated sodium carbonate solution was poured through the interior Liebig tube until the absorption space *qr* containing the glass beads was filled with the carbonate solution. By introducing the carbonate solution in this manner the part *mq* of the combustion tube is not moistened with carbonate solution. The finger was removed from the outlet and the carbonate solution allowed to drain out. The tube was filled and drained twice more in the same manner. The Liebig condenser tube was removed and the combustion tube again connected to the Drechsel wash bottles, care being taken that no carbonate solution dropped into the section *mq* of the combustion tube.

The first platinum contact was inserted into the opening *m* of the combustion tube and pushed back near the constriction *q*, in that part of the tube covered by the asbestos box. The platinum basket containing the asbestos was placed in the tube next to the first contact. The second contact was placed immediately behind the platinum basket.

The porcelain boat containing the weighed sample was next placed in the combustion tube, about 4 centimeters from the asbestos box. The weight of sample used varied from about 0.0150 gram to 0.0390 gram, depending upon the bromine content of the particular sample. It is not advisable to use large

samples as they tend to explode and produce carbonaceous deposits which must be burned out in a current of oxygen. Volatile liquids were weighed as usual in sealed tubes.

The platinum foil *e* (baffle) was next inserted in the combustion tube and placed about 6 centimeters from the oxygen inlet. The combustion tube was then connected to the oxygen inlet.

When the combustion tube containing the weighed sample was arranged properly, a steady stream of oxygen was allowed to flow through the tube and the solutions in the Drechsel wash bottles. The rate of flow was regulated so that each minute about 60 to 90 bubbles of gas issued from the solutions in the Drechsel wash bottles.

The top of the asbestos box was removed temporarily; the Terril fishtail burner *j* under the asbestos box was lighted, and the tube heated with a low flame until the part *mq* was dry and rather warm. The lid was again placed on top of the asbestos box. The flame under the box was gradually increased until the platinum contacts were heated to low redness.[8] A small, though rather intense flame *h* was placed under the baffle contact *e*, which was heated to a dull red color. The sample was then heated with a small flame *i*, and when it was entirely carbonized the temperature was increased until combustion was complete and no residue remained in the porcelain boat or, perhaps, only a small quantity of white ash. With some substances which do not oxidize readily it is advisable during the combustion to hold a piece of asbestos board or wire gauze above that part of the tube containing the boat. The temperature is thus increased sufficiently to produce complete combustion.

When the combustion was completed the flame under the porcelain boat was first extinguished and after about five minutes the flames under the asbestos box and the baffle contact were also extinguished. The lid of the asbestos box was removed and the tube allowed to cool. It requires usually about fifteen minutes to complete the combustion and about thirty minutes to cool the tube. When the tube had cooled to room temperature the flow of oxygen was discontinued. The safety stopcock *a* was opened and the Drechsel wash bottles and combustion tube disconnected. The products of the combustion

[8] Pregl, F., and E. Fyleman, Quantitative Organic Micro Analysis (1924) 111.

reaction were absorbed mostly by the solution in the combustion tube *qn* and the solution in the Drechsel wash bottle *k*. The porcelain boat, platinum contacts, and basket were removed from the combustion tube. The filling tube (interior tube of a Liebig condenser) was inserted in the upper end *mq* of the combustion tube and lowered down to the constriction *q*. The solution in the Drechsel bottle *l* was then poured through the filling tube into the combustion tube and then into a 400-cubic-centimeter beaker. To this solution were added the contents of the Drechsel wash bottle *k*, and also the wash waters obtained by washing (as usual) the combustion tube and Drechsel bottles with distilled water. As the amount of wash water used was not excessive the final volume of the solution was about 200 cubic centimeters, which is an appropriate amount.

The solution was then treated with eight drops of hydrogen peroxide and heated ten minutes on a water bath. It was cooled in ice water, and made neutral to litmus with nitric acid. An excess of nitric acid (2 cubic centimeters) was added, after which 4 cubic centimeters of silver nitrate (0.1 *N*) were added slowly. The mixture was filtered immediately through a Gooch crucible and the precipitated silver bromide washed with a 1 per cent solution of nitric acid. The filtrate was transferred to an 800-cubic-centimeter beaker and to it were added 5 cubic centimeters of nitric acid (free of halogens) and 5 cubic centimeters of iron alum indicator, which was acidulated slightly with halogen-free nitric acid. The solution was titrated [9] immediately with thiocyanate solution (0.1 *N*). The first appearance of a pinkish brown color was taken as the end point. In making this titration it is advisable to use a 10-cubic-centimeter burette graduated to $\frac{1}{20}$ of a cubic centimeter. A meniscus reader is also advantageous. The addition of silver nitrate and the titration should be done at room temperature.

RESULTS

In Table 1 is given a list of compounds analyzed by this modified combustion method. As shown by the data, the percentage of bromine as determined by analysis agrees rather closely with the calculated theoretical percentage of bromine.

This method seems to have several desirable features. As it requires only about two hours to make an analysis, the method

[9] Sutton, S., Volumetric Analysis, 2d ed. (1924) 184.

is rather rapid. When the apparatus has once been assembled no special extra equipment, such as a microbalance, is required.

The results seem to indicate that this is a rather satisfactory method.

TABLE 1.—*Determination of bromine by a modified combustion method.*

Compound.	Bromine.	
	Found.	Theoretical.
	Per cent.	*Per cent.*
Linolenic hexabromides:		
Alpha	63.02	63.32
Beta (liquid)	63.28	63.32
Linolic tetrabromides:		
Alpha	53.32	53.33
Beta	53.16	53.33
Gamma (liquid)	53.37	53.33
Delta	53.28	53.33
Brombenzene (liquid)	50.47	50.92
Bromoform (liquid)	94.89	94.85
Dibromanthracene	47.60	47.58
Tribromaniline	72.65	72.70
Ethylene bromide (liquid)	85.03	85.08
Dibrom chaulmoogramide	36.37	36.40
Dibrom chaulmoogra-*p*-toluide	30.13	30.21
Potassium salt of alpha linolic tetrabromide	50.10	50.13

SUMMARY

A modified combustion method for the determination of bromine in organic compounds has been described. The modification consists principally in using a platinum baffle and also a platinum basket containing asbestos fiber. The passage of a volatile substance through the asbestos fiber is retarded sufficiently for the substance to be cracked and decomposed completely, so that all the bromine is liberated before entering the carbonate absorption solution.

The essential features of this method are rapidity and ease of manipulation.

The method appears to give accurate results with both ring and long-chain compounds.

ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Apparatus for the determination of bromine in organic compounds.
2. Section of tube in asbestos box.

VITAL CAPACITY AND PHYSICAL STANDARDS OF STUDENTS OF THE UNIVERSITY OF THE PHILIPPINES

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THREE TEXT FIGURES

Knowledge of a definite normal standard for each essential and fundamental physical measurement of any race of people is indispensable in the study of divers problems pertaining to individual or collective human development and for the correct determination of all other standards, physical, psychical, or otherwise. Physical standards are of basic need for a right understanding and solution of the material fitness and human efficiency of the different social components of a people and race. They are necessary for the correct interpretation of the future possibilities and degree of probabilities of the race. Standards are essential for the determination of appropriate measures for physical training as well as for the academic adaptation of the youth of a country. In brief, standards are the essential working basis for the study of many highly important problems pertaining to the education, health, efficiency, and wealth of a people.

Various demands of greater or lesser practical importance and usefulness are urgently made upon those of us who are expected to study and pass upon the parity of the Filipino race with the people of other regions. These demands range from the simple question of dimensions and physical features to that of the most complicated mental and psychical qualities and characteristics of Filipinos. They are encountered every day in science, in commerce, in education and, in fact, in all endeavors and enterprises touching on the line of modern activities and progress. It is to be regretted that a large amount of

qualifying data and conclusions on standards has been propagated and even accepted at the present time as Filipino standards, when much of the information is based upon assumption, unsupported by fundamental study of true measurements from representative numbers of individuals. If we desire to lead an efficient, modern, national existence, hand in hand with progressive countries, it is urgently necessary that sound vital statistics be collected and properly studied, as they constitute the very foundation of the efficient working out of national existence.

Knowledge of the standard lung capacity, or vital capacity, is particularly important in the Philippines in its relation to the study of certain phases of the question of pulmonary tuberculosis, admittedly the greatest scourge of the race. Pioneer observers in other countries, such as Garvin, Lungsgaard, and several others, have repeatedly demonstrated the necessity for conducting comparative determinations of the actual vital capacity and of the standard capacity in the early diagnosis of pulmonary tuberculosis. The determination and the finding of the existence of subnormal lung capacity per se, even in cases with intrathoracic affections other than pulmonary tuberculosis, require definite knowledge of standard data. In the Philippines this question is of great importance because of the peculiar condition of seeming susceptibility or state of predisposition of the Filipino to pulmonary tuberculosis. The present high rate of morbidity and mortality from this disease in all parts of the Philippines appears to suggest very strongly that a close relation may exist between the undeveloped or subnormal vital capacity and the heightened degree of susceptibility to pulmonary tuberculosis.

Indices of physical development and fitness of the body, such as stature, body weight, and chest circumference, are obviously needed, not only with the minor purpose of knowing how the race stands in physique as compared with other races of the world, but also because the standards derived from such measurements may be of assistance in attempts to solve the national problem of physical education in the public schools of the country. These statistical data are even concerned with the questions of correlation of normality with degree of efficiency, and doubtless enter into the consideration of such problems as insurance and the selection of applicants for various services, military, industrial, or otherwise.

Neither the physical nor the developmental standards of Filipinos have ever been properly investigated and determined. Un-

fortunately, exact and reliable data are not available. Various scattered records are possessed by several institutions in the Islands, but no study of real significance has ever been conducted on such records.

The present work is presented with the definite statement that it is only a preliminary step toward or an introduction to the opening up of a field of investigation purporting to appraise and determine the physical and developmental standards of the Malay peoples and, more specifically, of the Filipino race. The department of anatomy of the University of the Philippines more than three years ago commenced work on measurements of the external body dimensions and the internal organs of still-born babies and premature deliveries, with the purpose of determining the condition of embryological and fœtal growth of Filipinos. The data so far gathered are limited, however, mainly because of the lack of men to undertake such work and because, consequently, the data so far gathered still fall short of the representative numbers requisite for useful report and summary. In connection with this, the department has a more comprehensive plan of undertaking a careful study of the physical condition of different groups, geographic or ethnic, of Filipinos with the purpose of better determining their developmental standards. However, much as the plan and purpose may mean, the department is seriously lacking in men for work of this kind, even with all the facilities already provided and arranged for by the department now available. Hope is entertained, however, that in the near future we may be granted such needed help for the proper determination of the much-needed standards.

It is partly because of the above reasons that the data dealt with in this preliminary study must be requisitioned from the department of physical education of the University of the Philippines. This department is conducting, yearly, measurements of some of the external body dimensions of Filipino students newly admitted to the university. The data do not include measurements of students of other nationalities. It would be of interest to know if these data pertain to that group of our population that may be called representative, and whether or not we are dealing only with a selected kind as far as physical development is concerned. No reliable answer can yet be given to this question; it can only be answered after careful study of different and more comprehensive data coming from all the various sources of the population, geographic and ethnographic.

We are using the records collected by the department of physical education. As is the case with any large collection of measurements, some errors arising from faulty technic were encountered in the examination of these records. These errors will be mentioned in the course of this study. Naturally they will to a certain extent affect some of our findings, but to no greater extent than should be expected in such work. It is desired again to emphasize the fact that this study is only a preliminary report, and that the errors mentioned have been fully recognized and considered, with the intention however of checking our findings more carefully in the future with data and measurements more systematically collected by ourselves.

MATERIALS FOR STUDY

The series of measurements dealt with were taken from seven hundred thirteen university students, five hundred sixty-four males and one hundred forty-nine females. This university-student population is made up of heterogeneous groups of young men and women coming from different parts of the Philippines. This heterogeneity will provide a general index of comparison for later investigations on regional studies of the Filipino people. The regional distribution of the university students examined is as follows:

	Per cent.
Ilocano region: Ilocos, La Union, Abra, Isabela, and Zambales Provinces	11.44
Pangasinan region: Pangasinan Province	8.05
Pampanga region: Pampanga and Tarlac Provinces	5.28
Tagalog region: Nueva Ecija, Bulacan, Batangas, Cavite, Laguna, Rizal, Tayabas, Mindoro, and Bataan Provinces	27.75
Bicol region: Camarines, Albay, and Sorsogon Provinces	0.63
Eastern Visayas region: Leyte, Samar, Cebu, Oriental Negros, and Bohol Provinces	3.81
Western Visayas region: Occidental Negros, Capiz, Iloilo, and Romblon Provinces	9.95
Mindanao region: Palawan, Zamboanga, and Misamis Provinces	0.84
City of Manila	32.20

The group studied comprises a blood intermixture, including Filipinos of the purely Malay type to those of close or distant Chinese and Spanish lineage. It also includes individuals with indefinite hybridism from among these principal constituent elements of mixed lineage.

The physical build of this group of university students, both male and female, varies somewhat, as can be seen from their external features alone. There are those of slender build, with poorly developed musculature, with apparently a disposition toward leading a sedentary life. Others possess good physique, with the body musculature fairly well developed. The latter individuals (who, by the way, constitute the marked minority in this series) are commonly known as the "athletic type." Intermediate between these two types are those who possess moderately developed musculature, and they seem to comprise the majority of the students. Among the females, however, there is apparently a predominance of the weaker and slender type, who appear indisposed to regular athletic exertion. This type seems to be more frequently observed among those coming from private schools.

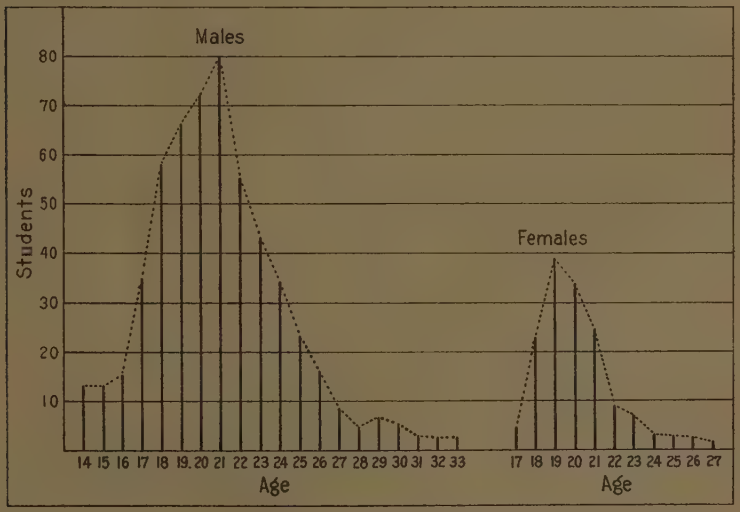

FIG. 1. Age frequency distribution of university students (University of the Philippines).

The extremes in age of males were 14 and 33 years, with the majority between 18 and 22; in women the age limits were 17 and 26 years, with 18 to 20 as the common mode. Figure 1 shows the age-frequency distribution for both male and female students. It is seen that the male students have a wider range of age than do the female students and that the former begin their university education at an earlier age than do the latter, and also that they continue their university attendance

for a longer period. The mean age of the male students in the University of the Philippines is 21 years, whereas that of the female students is 19 years.

TECHNIC OF MEASUREMENT

The vital capacity (lung capacity) is taken with a spirometer that gives accurate readings and registers the amount of air that can be exhaled after a maximum inspiration. This test is repeated three times with the same instrument, allowing an interval of several minutes for rest between tests. The average of the three readings is taken to represent the vital capacity of the individual; however, most workers take the maximum record made by the individual instead of the average as the vital capacity. For this reason, our records are a few hundred cubic centimeters lower than those of other workers.

The standing height is measured with a stadiometer provided with a horizontal slide moving at a right angle on a graduated perpendicular pole mounted on a box. The height is easily taken by having the individual stand erect and barefooted on the box and placing the slide on the top of his head. For taking these measurements, the head and figure of the subject are held erect, with the eyes to the front and the heels together. This position is better secured by having the back of the head, the spine of the seventh cervical vertebra, the buttocks, and the heels of the individual in contact with the measuring pole of the stadiometer.

The determination of the sitting height is also obtained with the stadiometer; but, instead of having the subject stand on the box, he is made to sit erect upon it, and the reading is made after the horizontal slide is placed on top of the head.

A steel tape measure is used for the determination of the chest circumference, both at rest and during maximum inspiration. The measurement of the chest is always made at the horizontal level of the nipples and with the subject standing. Only one measurement is taken in each case. The chest circumference of females is also measured as nearly as possible at the level of the nipple line. The variability in their case however is obviously influenced by the changeable position of the female breast, and such variation is given due consideration later.

The weight of the body is recorded by means of a platform scale with a high bar for appropriate reading. This scale carries the metric graduation and is sensitive to a fraction of

a gram. The weight of the males is taken without clothing; in the case of the females, however, it is regularly taken with the clothing and the necessary deduction is made of the approximate weight of the clothing, to get the net body weight.

NATURE OF INVESTIGATION

Some of the basic questions that we had in mind in our study are (*a*) the determination of the physical or constitutional make-up of the students of the University of the Philippines, (*b*) whether or not these students belong to the picked class in the Philippines as far as physical build is concerned, and (*c*) the relative standing of the physical development of Filipinos compared with the standards of the other oriental races and also with those of the occidental people.

The findings and discussions in this paper are limited to stature, body weight, build, vital capacity, chest circumference, and constitution. The other phases of the study will be presented in later papers which will also deal with the correlation of lung capacity and body weight with some of the most important external body measurements.

STATURE

We found the mean stature of the group of male Filipino university students to be 163.3 centimeters; the modal class for stature in the group, between 158 and 164 centimeters; the standard deviation, 5.91 centimeters. This degree of deviation implies only a fair degree of homogeneity in the class under study.

Results of a comparative study of the stature of several groups of university students of other countries (as gathered from references to available literature) and that of our group of students are presented in Table 1.

TABLE 1.—*Stature of various groups of university students.*

Group.	Stature.	Difference.	
	cm.	*cm.*	*P. ct.*
University of Oxford	176.5	13.2	8.1
Harvard University	175.9	12.6	7.7
Leland Stanford Junior University	173.6	10.3	6.3
University of the Philippines	163.3		

It will be noted from Table 1 that the mean height of students of Oxford, Harvard, and Stanford Universities, as compared with the stature of Filipino students, is around 7 per cent, or

about 11.5 centimeters greater. This difference is in accord with the commonly admitted view that Filipinos as a whole are shorter in stature than are Americans and Britons.

The data on standing height, compared with that of nonuniversity groups of European nationals, are given in Table 2.

TABLE 2.—*Stature of nonuniversity (military) groups of various nationals, compared with that of students of the University of the Philippines.*

National.	Stature.	Difference.	
	cm.	*cm.*	*P. ct.*
Scotch	172.5	9.27	5.67
English	172.1	8.81	5.39
German	172.0	8.77	5.37
Irish	171.4	8.09	4.95
Polish	169.4	6.14	3.76
French	168.6	5.32	3.26
Hebrew	166.9	3.64	2.23
Italian	165.2	1.91	1.17
University of the Philippines	163.3		

It is obvious from Table 2 that the stature of Filipino university students is around 6 per cent less than that of the northern or northwestern European nationals, and that it is around 2 per cent lower than that of the Latin or the Ibero-Mediterranean peoples. It appears from Tables 1 and 2 that, as far as male stature is concerned, that of the university group, for both the Britons and the Americans, is superior to that of the military groups.

Standing height of Filipinos compared with that of some of the Mongolian and oriental races of nonuniversity groups (records on students not being available) shows certain differences, as indicated in Table 3.

TABLE 3.—*Standing height of nonuniversity groups of Mongolian and oriental races compared with that of students of the University of the Philippines.*

Race.	Stature.	Difference.	
	cm.	*cm.*	*P. ct.*
North Chinese	167.1	3.8	2.3
South Chinese	163.1	—0.2	—0.1
Koreans	162.2	—1.1	—0.7
Siamese	160.8	—2.5	—1.5
Japanese	159.7	—3.5	—2.1
University of the Philippines	163.3		

The North Chinese, the tallest of all the Mongolian races studied, show but little difference (not quite 4 per cent) over the Filipino standard. The figures for stature of the North Chinese was obtained from soldiers, as were also those of the other oriental races except the Siamese, which were obtained at random from the civilian population. The standing height of the South Chinese, however, shows close relationship with that of Filipinos (163.3 for the Filipinos, and 163.1 for the South Chinese), presenting therefore a difference of only a fraction of 1 per cent. This particular finding seems to point to the existence of relationship between the people of the two groups, as has been asserted and accepted by many historians and ethnographers of Asia and the Malay Peninsula.

The stature of the Japanese, the Koreans, and the Siamese is seen to be distinctly lower than that of the university-student group in the Philippines. This statement appears to be borne out by statistical comparison, in spite of the fact that our data for the first two were obtained from the military population of those two races. The difference between Filipino and Japanese stature amounts to a little over 2 per cent. Between the Filipino and the Siamese it is nearly 1.5 per cent, and between the Filipino and the Korean it is 0.7 per cent.

Statistical studies on stature have evolved the general classification of the average height of men shown in Table 4.

TABLE 4.—*Average height of men.*

	cm.
High stature	Over 170
Stature above the average	165 to 169
Stature below the average	160 to 164
Low stature	Under 160

According to this classification the standing height of the students of the University of the Philippines, as shown by our records, would fall under the group of "Stature below the average."

BODY WEIGHT

The average body weight of Filipino university males is 50.75 kilograms; the modal class for weight ranges from 45 to 55 kilograms. This class comprises 61.2 per cent of all of the male students. The standard deviation existing in our group for the body weight is 6.22 kilograms. It has been found that individual variation in body weight is more marked and more irregular in our group of university students than in other, foreign university groups.

A study of our standards on body weight, including actual and percentage differences, compared with those of other university groups of several occidental races, has afforded the interesting comparative figures shown in Table 5.

TABLE 5.—*Body weights of student groups in other universities compared with those of students of the University of the Philippines.*

Group.	Body weight.	Difference.	
	kg.	*kg.*	*P. ct.*
University of Oxford	68.5	17.75	34.9
Leland Stanford Junior University	68.4	17.35	34.1
Harvard University	64.5	13.75	27.1
University of the Philippines	50.6		

It will be seen from Table 5 that our university males have an average body weight that is 35 per cent less than that of the English males of Oxford or that of the American students of Stanford, and about 27 per cent less than the average body weight of the students of Harvard. These differences amount to around 17.5 kilograms more for Oxford and Stanford and 13 kilograms for Harvard over and above the Filipino weight.

The body weight of our students, compared with that of groups of European races, taken from nonuniversity populations, is seen to be no less striking (see Table 6).

TABLE 6.—*Body weight of nonuniversity groups among other nationals compared with that of students of the University of the Philippines.*

National.	Body weight.	Difference.	
	kg.	*kg.*	*P. ct.*
German	67.2	16.4	32.3
Polish	66.0	15.2	29.9
English	65.8	15.0	29.5
Scotch	65.7	14.9	29.3
Irish	64.8	14.0	27.5
French	64.5	13.7	26.9
Italian	62.6	11.8	23.2
Hebrew	62.5	11.7	23.0
University of the Philippines	50.8		

Following the comparison farther, with other races, such as the Mongolians, we found that there also exist certain differences that must be emphasized in their relation with the weight standard of the Filipino university students. Table 7 brings out clearly these differences for some of the Asiatic races.

TABLE 7.—*Body weight of groups among Mongolians compared with that of University of the Philippines students.*

Group.	Body weight.	Difference.	
	kg.	*kg.*	*P. ct.*
North Chinese	59.3	8.5	16.7
Koreans	58.6	7.8	15.3
Japanese	55.5	4.7	9.2
South Chinese	50.6	—0.2	—0.3
University of the Philippines	50.8		

From Table 7 it is seen that the principal Mongolian races, except the South Chinese, have a greater body weight than do the students in the University of the Philippines. This difference with respect to the Japanese is a point of some importance, because of the fact that, while the Filipinos exceed them in stature by nearly 4 centimeters (the stature of the Japanese is 159.7 centimeters and that of our group is 163.3 centimeters), yet comparison of the body weights shows that the Japanese are 9.2 per cent heavier, a difference amounting to about 4.7 kilograms. Such finding speaks strongly of low body nutrition or of poor body development in our students, and very likely also of Filipinos in general.

It should be mentioned that, for a study on stature and body weight of various races, we do not consider the comparison between groups of university students and military groups entirely satisfactory and free from criticism; but, in the absence of records obtained exclusively from the student populations of other races, we had to make use of the standard data available, so long as such records were to a fair degree comparable and bore a proximal relationship to those obtained from university groups. The standard physical measurements recorded for English and for American students demonstrate a higher degree of physical development than do those of their military populations. It would seem therefore that the physical records of the armies of other races would be to a certain degree comparable with the standard of measurements obtained from our group of university students. It might be well also to mention in this connection that the body measurements and the degree of physical development of our university students probably do not maintain the superior development over the military standards of our own race that exist among the English and the Americans.

UNIT WEIGHT AND BUILD

Some of the most important observations met with in the study on stature and body weight of Filipinos, as compared with those of other university groups and races, are those related to the serial excess of absolute standards of height and weight of the latter over our group, which seem to reflect considerable light upon the nutritional condition of the Filipino race.

The weight of the body, considered in relation to stature, offers one of the most important indices of physical condition, or build; that is, the index of physical efficiency. It is to be observed from the foregoing tabulations that the excess in the stature of the students of Oxford, Harvard, and Stanford over that of the Filipino group is associated with marked excess of body weight to a degree much greater than we expected to find; thus, while the differences in height over the Filipino standards were 8, 7.7, and 6.3 per cent, respectively, those of body weight recorded a much higher degree of superiority over the Filipino weight, amounting in actual figures to 34.9, 27.1, and 34.1 per cent, respectively, for Oxford, Harvard, and Stanford.

Our findings appear to show that body nutrition and body development in the group under study are considerably lower than in the groups of English and American students; that is, the lesser body weight of our students is too much out of proportion to their shorter stature, when compared with the difference in foreign students. This poorer condition of nutrition and development would indicate that, for a given unit of stature, there would be a corresponding lower body weight for Filipino students. The body weights per centimeter of stature of the university and the military groups are shown in Table 8.

TABLE 8.—*Body weight per centimeter of stature of University student groups and foreign military groups.*

Group.	Grams.
Leland Stanford Junior University	390.8
University of Oxford	389.2
Harvard University	372.8
University of the Philippines	311.0
German	390.8
Polish	390.8
French	383.0
English	382.2
Scotch	382.2
Italian	379.3
Irish	379.2
Hebrew	376.6

The figures in Table 8 show conclusively that the per centimeter unit of stature of the students of the University of the Philippines carries an equivalent of only 311 grams of body weight, whereas in the case of English and Americans the equivalents are around 384 grams. There is a difference therefore of more than 70 grams per centimeter unit of stature. This fact obviously indicates that the state of nutrition of Filipino students is far below that of students of occidental races. The absolute expression of equivalents for the nonuniversity groups of various races points also unequivocally to the poorer state of body nutrition and development of our students, and probably also of the Filipino people as a whole.

If this study is carried farther and the unit relation of stature to body weight as observed in some of the oriental races is compared with that for our students, it will be found that there exist also noteworthy differences which reflect the lower degree of body nutrition and physical state of the Filipino students (see Table 9).

TABLE 9.—*Body weight per centimeter of stature of Orientals and of University of the Philippines students.*

Group.	Grams.
Koreans	361.7
North Chinese	354.0
Japanese	349.0
South Chinese	310.4
University of the Philippines	311.0

The most important finding in the data for the oriental or Mongolian races is the existence again of differences that place our standard of measurements below the standards of neighboring races. Despite the fact that the stature of the Japanese is 3.5 centimeters, or 2.1 per cent, less than that of the Filipino, yet the body weight of the former is greater by 4.2 kilograms, or 9.2 per cent. The Japanese weight per centimeter unit of stature amounts to 249 grams, in contrast to 311 grams for the Filipino students. The stature of the Korean is a fraction of 1 per cent lower than the Filipino height, and yet his body weight is 15.3 per cent greater. The stature and weight of the South Chinese are closely similar to the standards for our group and, further, their per centimeter unit of stature is almost parallel to that of the students of the University of the Philippines. A considerable difference is observed in the data for the North Chinese; their stature is only 2.3 per cent higher than ours, yet their body weight is greater by 16.7 per cent.

It appears, therefore, that we must accept and admit the conditions revealed by the comparative figures given above. They are unfortunately against the physical standing of our race, as proven by mathematical analysis of actual measurements of a fair number of individuals, from a fairly known degree of social standing. The existence of such conditions can be explained, perhaps, by such factors as social standing, climate, and financial standing, which factors should be carefully studied so that institutions responsible for the welfare and well-being of our race can devise necessary and definite measures for the effective correction and improvement of such conditions.

The determination of the index of build for any particular group or class of people takes into consideration the body weight in relation to stature. According to Guild and Quetelet the formula that is most satisfactory for the solution of the index of build is one that takes the ratio of weight divided by the second power of the stature, namely:

$$\frac{\text{Weight } (\times 1{,}000)}{\text{Height (sq.)}} = \text{Build.}$$

In accordance with this formula we have found the following indices of build for the various university and racial populations that we have been considering:

TABLE 10.—*Index of build for university student groups and foreign military groups.*

Group.	Index.
Leland Stanford Junior University	22.33
University of Oxford	22.11
Harvard University	21.55
University of the Philippines	19.12
Koreans	22.32
Japanese	21.95
North Chinese	21.26
South Chinese	19.04
Polish	23.10
Italian	22.99
French	22.85
German	22.71
Hebrew	22.68
English	22.24
Scotch	22.20
Irish	22.16

Table 10 shows definitely that the body development of Filipino students is below that of the university or nonuniversity groups of the other races listed. The only racial group shown to

possess the same index of build as that of the Filipino is the South Chinese.

VITAL CAPACITY

The average vital capacity that we found for the male students of the University of the Philippines is 2,262 cubic centimeters. The modal class, covering 35.3 per cent of the males in our series, ranges from 1,600 to 2,000 cubic centimeters. The standard deviation in the vital capacity of this group amounts to 66.93 cubic centimeters.

In our study of the various standards on vital capacity of the different groups of university students of other nationalities we were greatly astonished to find that the record for our group ranks far below the standards of the others. This was also found to be true on comparison with some of the oriental races, but the differences are not so glaring as are those from the other data.

The average vital capacity of our students is only 2,262 cubic centimeters; that of the Oxford, Harvard, and Stanford University students averages as high as 4,315, 4,651, and 4,646 cubic centimeters, respectively. There exist, therefore, the overwhelming excesses of 2,055 cubic centimeters for Oxford, 2,389 cubic centimeters for Harvard, and 2,384 cubic centimeters for Stanford over the vital-capacity standard of our university students. These differences, expressed in percentages, are given in Table 11, both for the university groups and for some of the nonuniversity oriental groups.

TABLE 11.—*Vital capacity of University of the Philippines students compared with that of Mongolian nonuniversity groups.*

Group.	Vital capacity.	Difference.	
	cc.	*cc.*	*P. ct.*
Harvard University	4,651	2,389	105.6
Leland Stanford Junior University	4,646	2,384	105.4
University of Oxford	4,315	2,053	90.7
Americans (nonuniversity)	3,602	1,340	59.2
North Chinese	3,180	918	40.5
South Chinese	2,518	256	11.3
University of the Philippines	2,262		

Comparison of the figures in Table 11 shows the superior volumetric lung contents of 90 per cent for Oxford and 105 per cent for both Harvard and Stanford over the vital capacity of our group. In other words, this finding means that English

and American students can inspire double the amount of air that Filipino university males can take in, and that the lungs of the former groups have twice the degree of expansion, compared with the lungs of Filipinos. This is again a finding on actual conditions that is to be regretted, but which we must accept as it is borne out by the results of the analytical study of actual measurements.

It was not possible to continue the parallel study of the standards on vital capacity of the other races, because no complete data on the subject were obtainable in the statistical reports at our disposal.

The significant fact in connection with the vital capacity of Filipino students is the parallel between their capacity standard and their stature and body weight standards, as compared with the corresponding standards of other nationalities. It has been stated earlier in this paper that the body weight of Filipino students falls below and is out of proportion to the fall in stature observed in the students of Oxford, Harvard, and Stanford and that, though the fall in stature is only around 7 per cent, the fall in weight is around 35 per cent. If the vital capacity is examined along the same lines, it will be found again that the capacity of Filipino university students is much lower, even about 50 per cent of the vital capacity of English and American university students.

The finding on the vital capacity is a practical demonstration of facts on the vital resistance of Filipino university students and, we venture to say, of Filipinos in general. It is probably reasonable to presume that, if differences exist in the standards of the various social groups of the Filipino race, the vital capacity of the university population should present a higher standard than we would expect to find from the rest of our population, with the possible exception of the military group. The too inferior relative standing of the university capacity standard, in relation to other races, is regrettable, but the finding should be seriously taken into consideration by those among us who are responsible for the promotion of the health and the well-being of the people, and more particularly by those called upon to solve the vital national question of pulmonary tuberculosis. The very poor standard of vital capacity found in Filipino young men may be one of the most important factors contributing to the extraordinarily high rate of morbidity and mortality from pulmonary tuberculosis.

CHEST CIRCUMFERENCE

Chest circumference is a dimension of some importance, from the medical, the military, and the anthropological points of view. It is sometimes used to measure the lung capacity, and it serves also in some cases as an index for the determination of certain pulmonary diseases. This measurement is employed in obtaining the index of robustness, an index that is generally considered to offer a fair measure of the vital resistance of the individual.

The mean chest circumference found by us in our group of university males is 79.9 centimeters. The modal class of this measurement is from 78 to 82 centimeters and comprises about 39 per cent of the males in this series. The standard deviation of this dimension is 5.59 centimeters.

A comparative study of the Filipino standard chest circumference and of the records for other racial groups resulted in the figures presented in Table 12, which show the actual differences computed in percentages.

TABLE 12.—*Chest circumference of Filipino university students compared with that of other racial groups.*

Group.	Chest circumference.	Difference.	
	cc.	*cc.*	*P. ct.*
Siamese	84.5	4.6	5.7
Korean	82.9	3.0	3.7
Japanese	82.2	2.3	2.9
North Chinese	81.4	1.5	1.9
South Chinese	81.3	1.4	1.8
University of the Philippines	79.9		
Polish	90.4	10.5	13.1
German	89.5	9.6	12.0
Italian	88.9	9.0	11.3
Irish	88.7	8.8	11.0
Scotch	88.6	8.7	10.9
French	88.5	8.6	10.8
English	88.2	8.3	10.4
Hebrew	87.5	7.6	9.5

The standard of chest circumference for Filipinos is seen to be lower than that of any of the other races. We could not compare our records of this measurement with those of other university groups because we were unable to locate standard data on chest circumference for university males of other races.

CONSTITUTION, OR ROBUSTNESS

The index of constitution, or robustness, of individuals depends upon certain relations of stature, weight, and chest circumfer-

ence. This index is generally calculated according to the following formula:

Constitution=Stature in centimeters — Chest circumference in centimeters+Weight in kilograms.

The table of standards commonly accepted by known authorities offers means for the right interpretation of results as obtained by the above formula for the determination of constitution. Table 13 shows standards as proposed by Pignet.

TABLE 13.—*Indices of constitution, or robustness, according to Pignet.*

Class A, under 10, a very powerful constitution.
Class B, 11 to 20, good constitution.
Class C, 21 to 25, mediocre constitution.
Class D, 26 to 30, weak constitution.
Class E, 31 to 35, very weak constitution.
Class F, over 36, bad constitution.

On the basis of the above formula, we find that the robustness, or constitution, of male students of the University of the Philippines reaches the low index of 32.6. According to the classification of Pignet this index value falls under the class of "very weak constitution." This result is only to be expected from the figures for the other Filipino standards as compared with the physical measurements of other races. The following comparative list of the indices of constitution (Table 14) further emphasizes the lower records of Filipinos as compared with those of others. It is to be noted that the lower the expression of values the better the degree of constitution, or robustness.

TABLE 14.—*Comparative constitution indices.*

Nationality.	Index.
Polish	12.9
Italian	13.7
German	15.3
French	15.6
Hebrew	16.9
Irish	17.8
English	18.1
Scotch	18.2
Korean	20.7
Japanese	22.0
North Chinese	26.4
South Chinese	31.1
University of the Philippines	32.6

No index of constitution is available for foreign university groups because of the lack of data on chest measurement on which this index is partly computed; but probably the English

and American student groups possess better constitution, or robustness, than do the military population, their other physical standards being superior. Table 14 demonstrates that the student population in the Philippines is unfortunately far below that of other races of the world in comparative constitutional standing, and it behooves us earnestly to study the question of improving the deplorable physical development and body nutrition of the Filipino race.

SUMMARY OF FINDINGS IN THE MALE GROUP

Our findings and results for the male group are summarized in Table 15.

TABLE 15.—*Summary of measurements of Filipino males.*

Measurements.	Means.	Modal class.	Standard deviation.
Stature.....cm..	163.3	158- 164	5.91
Body weight.....kg..	50.6	45- 55	6.22
Vital capacity.....cc..	2,262.0	1,600-2,000	66.93
Chest circumference.....cm..	79.9	78- 82	5.59
Sitting height.....cm..	85.2	83- 89	5.11

The indices of the students of the University of the Philippines are: Body weight per unit stature, 311 grams; build, 19.1; and constitution, or robustness, 32,6.

TABLE 16.—*Differences in percentage of physical standards.*

Group.	Stature.	Weight.	Vital capacity.	Chest circumference.
Oxford	8.1	34.9	90.7	.....
Harvard	7.7	27.1	105.6	.....
Stanford	6.3	34.1	105.4	.....
North Chinese	2.3	16.7	40.5	1.87
South Chinese	—0.1	—0.3	11.3	1.87
Japanese	—2.1	9.2	.....	2.87
Korean	—0.7	15.3	.....	3.75
Siamese	—1.5	.....	.....	.....
Scotch	5.67	29.3	.....	10.88
English	5.39	29.5	.....	10.28
German	5.37	32.3	.....	12.01
Irish	4.95	27.5	.....	11.01
Polish	3.76	29.9	.....	13.14
French	3.26	26.9	.....	10.76
Hebrew	2.23	23.0	.....	9.51
Italian	1.17	23.2	.....	11.26

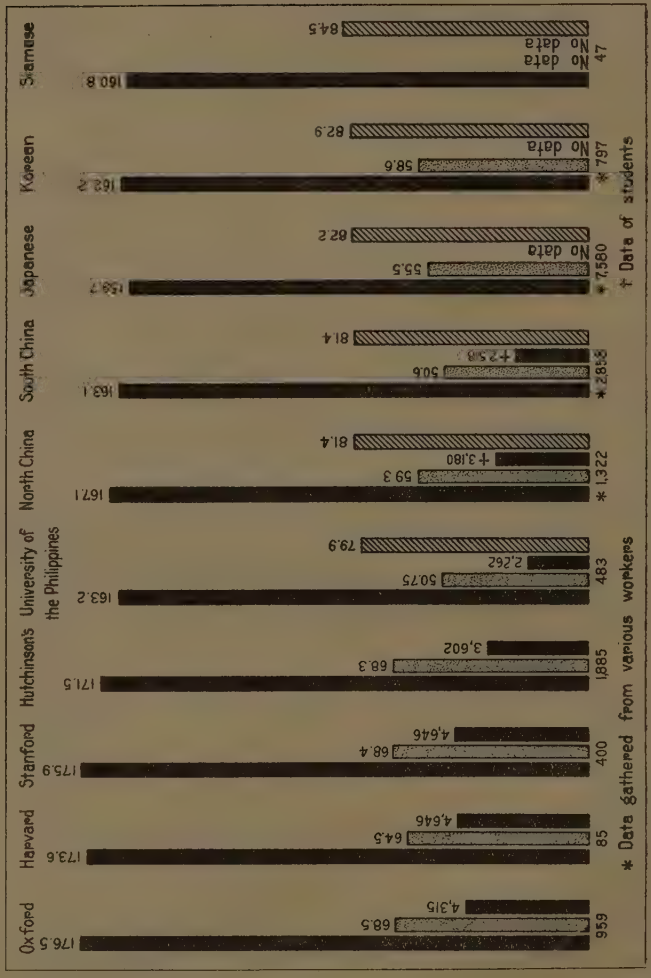

FIG. 2. Graphic comparison of physical measurements of several university groups together with those of some oriental races (male).

The differences in percentage of the physical standards that the university and nonuniversity groups of other races show over the physical standards found by us for the University of the Philippines are expressed in Table 16. The few negative percentage values encountered in the computation of this table are indicated by the minus sign.

Table 17 is a comparative summary of Filipino physical standards obtained for the student group under study and for those of other races from university and nonuniversity populations. (See also fig. 2.)

TABLE 17.—*Summary of physical standards of Filipino male university students compared with those of other races.*

University group.	Stature.	Weight.	Weight per unit stature.	Build.	Vital capacity.	Chest circumference.	Constitution (robustness.)
	cm.	*kg.*	*g.*		*cc.*	*cc.*	
University of the Philippines	163.3	50.8	311.0	19.1	2,262	79.9	32.6
Oxford	176.5	68.5	389.2	22.1	4,315	------	------
Harvard	173.6	64.5	372.8	21.5	4,651	------	------
Stanford	175.9	68.4	390.8	22.3	4,646	------	------
North Chinese	167.1	59.3	354.8	21.3	3,180	81.4	26.4
South Chinese	163.1	50.6	310.4	19.0	2,518	81.4	31.1
Japanese	159.7	55.5	349.0	22.0	------	82.2	22.0
Korean	162.2	58.6	361.7	22.3	------	82.9	20.7
Siamese	160.8	------	------	------	------	84.5	------
Scotch	172.5	65.7	382.2	22.2	------	88.6	18.2
English	172.1	65.8	382.3	22.2	------	88.2	18.1
German	172.0	67.2	390.8	22.7	------	89.5	15.3
Irish	171.4	64.8	379.2	22.2	------	88.7	17.8
Polish	169.4	66.0	390.8	23.1	------	90.4	12.9
French	168.6	64.5	383.0	22.8	------	88.5	15.6
Hebrew	166.9	62.5	376.6	22.7	------	87.5	16.9
Italian	165.2	62.6	379.3	23.0	------	88.9	13.7

DISCUSSION OF FINDINGS

The very noticeable inferiority of Filipino physical standards compared with the standards of other racial groups referred to in this work indicates a deficient, low body nutrition in Filipinos and a serious lack of regularly conducted physical exercise.

The degree of inferiority observed in the various standards seems to show that it is the weight element or the weight per unit-stature ratio that is markedly low in our group. This fact has been repeatedly emphasized in this paper. Low body weight may of course be due to various factors; such as (*a*) the existence of a chronic disease that causes certain metabolic disturbances and produces emaciation, (*b*) the presence of certain parasites claimed to be peculiar to the Tropics and which

tend to undermine the health of the individual harboring them, or (*c*) actual undernourishment.

The particular group now under study belongs to the social population of the country that is expected to possess better body nutrition than any other social group of the race. University students, as a general rule, come from families that are fairly well to do and are in financial position to provide their children with better support and better nourishment than the majority of our children can have. In fact, our University students should belong to the classification of "picked class," as far as nutritional possibilities are concerned, and their standards should be better than those of the larger groups of our population. It is presumable, therefore, that the standards on physical data of the other social groups of the Filipino race would fall below those shown by the records of the students.

Deficient body nutrition in these students does not appear to be due to the presence of chronic diseases among them. The students of the University of the Philippines are subjected to a rather thorough physical and medical examination at the opening of every academic year. Those found suffering from some chronic disease are either not accepted or are recommended to leave the school for proper treatment. Therefore, it is fair to assume that the data here reported are records from a normal group and that the deficient body nutrition observed from the study of their standards is probably not due to the presence of chronic disease among them.

We do not consider that parasitic infection is an important factor in producing the poor physical condition of our students. It is believed that these university students are living in fairly good sanitary and hygienic surroundings, the majority being members of fairly well-to-do families, and that the degree of exposure to which they are being or have been subjected is probably slight, compared with the greater mass of the inhabitants. Certainly, even if some of them were infected, the number would probably not be sufficient greatly to influence the average or the mean body weight of the whole group. A survey of the incidence of parasitic infection among students would be interesting and important, especially if the extent of the influence that such parasitic infection exerts upon the condition of low body nutrition among the students of the University of the Philippines could be determined.

We are inclined to believe that undernourishment in Filipino students, due to insufficiency in form or kind of subsist-

ence, is the most important contributing factor in causing underweight in our university group. There is probably not so much insufficiency of food and nourishment as there is lack of balance in the diet of Filipinos. Much preliminary work has been carried out on the determination of a balanced diet for Filipinos, and it is admitted that there is lack of a properly balanced diet in the daily subsistence of Filipinos in general. In the work of Roxas and Collado on the Filipino diet, as conducted on some of the students and members of the families in the College of Agriculture at Los Baños, the following assertions are worthy of note:

> * * * in what we would consider a good Filipino diet, grain products supply 75.16 per cent of the calories, while animal products supply only 11.35 per cent * * * that animal protein constitutes 30.88 per cent of the total protein and that the grains furnish over one-half (5.10 per cent) of the total protein. While the vitamine carriers in the American diet (eggs, milk, cheese, vegetables, butter, fruits) furnish 33.99 per cent of the total calories, in the Student Mess dietary the vitamine carriers constitute only 10.55 per cent, and in the diet of the peasant families they are in even smaller proportion, only about 5 per cent. It is thus apparent that the so-called protective foods constitute only a small percentage of our diet. Only about 15 per cent of our food, as against 40 per cent of the American, is of animal origin. Milk and dairy products, which according to McCollum, are the protective foods *par excellence*, constitute an insignificant part of our dietary.

The above conclusions of Roxas and Collado are sustained by other workers who have done work on the quality and value of Filipino foods; for instance, Aron and Concepcion. They agree that the main defect in the Filipino's every-day food is lack of proper balance, with special reference to the limited amount of vitamine and calcium carriers in the ordinary diet. Table 18 on dietary standards of Filipinos and of other races shows that the diet of Filipinos is not deficient in caloric value, but the mixture appears to be wrong.

TABLE 18.—*Comparison of dietary standards in different countries.*

[Langworthy's compilation.]

Country.	Occupation.	Protein.	Calories.
United States	Farmers	71.5	2446.5
Canada	Laborers	77.2	2486.5
Japan	do	87.2	2190.0
China	do	91.0	3400.0
Egypt	do	112.0	2825.0
Congo	do	108.0	2812.0
Philippines	Students (Ag).	78.1	2675.0

It is believed that most Filipinos have not yet learned to recognize the importance of certain articles of food that are highly essential for the proper upbuilding and development of the body. The actual condition is that, though those essential food articles are at present obtainable, the prices are prohibitive for the greater portion of our people, and their use and consumption are, therefore, far from general. There seems to exist the vicious circle of lack of an effective campaign for the consumption of the proper food on the one hand and lack of sufficient production of those essential constituents of diet owing to slight demand on the other. This condition has the aggravating consequence of an almost permanent high rate of prices. These principal factors in the vicious circle must first be remedied, and the millions of families in their search, cultivation, and selection of food articles must be effectively influenced if it is intended that these essential constituent elements be included in the daily diet of the general mass so that body development and body efficiency may reach the maximum.

We feel positive that the much lower standard of vital capacity demonstrated by the physical records of Filipino university males is due to the serious lack of regularly conducted physical exercise among the great mass of our children and young people. There is great need of exercise that will help bring about greater expansion of the chest and thus produce greater capacity for intake of air in the alveoli of the lungs. Taking into consideration the still serious question of pulmonary tuberculosis that affects a considerable portion of our population, this problem of physical and respiratory exercise becomes of paramount importance. It is believed that there is positive hope of decreasing the morbidity from pulmonary tuberculosis if the resistance of the lungs be strengthened by general prescription and careful supervision of correct physical and respiratory exercise. Such a campaign must be based, of course, on improved dietary provision for the people.

Physical exercise indifferently and irregularly followed at variable intervals, as is the practice in some of the schools in the Islands, would not bring about good chest and lung expansion in our children. Moderate respiratory or pulmonary exercise should be prescribed, together with the routine physical and calisthenic regimen in our schools. It is believed that the calisthenic and other exercises prescribed in the public schools are

not sufficiently supervised and uniformly regulated to effect fair development of the body musculature and to produce proper expansion of the chest. The practice of conducting interscholastic athletic competitions in the different regional groups of the Philippines, although beneficial socially, educationally, and physically, is not exactly productive of generalized and wholesale improvement in the physical build of the great mass of our population. Such competition probably results in the physical betterment of a few, only a small fraction of the mass of students in the public schools.

Physical exercise should be provided for a much larger part of our population. This does not mean that the interscholastic competitions are undesirable; on the contrary, they should be promoted in such manner as to serve as a stimulus toward a general love for out-door exercise and sports, and they should be made more comprehensive so that greater benefits may be derived from them. It is certainly a matter for pride that in the Far Eastern Athletic Meet among the oriental races conducted in the last few years, Filipino athletes have been credited with winning a large number of points from their competitors. However, it is regrettable that, when the physical build and the vital capacity of the same contending oriental peoples are compared, Filipinos fall behind the others. In other words, the paradox is presented of the Filipinos, though victors, being physically inferior to their vanquished foes. Therefore, we should strive for the wholesale and general physical improvement of the Filipino race.

PHYSICAL MEASUREMENTS OF FEMALE STUDENTS OF THE UNIVERSITY OF THE PHILIPPINES

We are skeptical in reporting the observations and findings met with in the study of our data on the female group of our students. This is due to the fact that the number of this group is not sufficiently comprehensive to admit of valuable statistical interpretation, as the female records cover but 166 individuals. Furthermore, we found several questionable points, arising either from the procedure of recording or from the peculiar individual reaction of the subjects during the process of measurements. The female students seem to have shown indifference, hesitation, or bashfulness in the recording of certain measurements and failed to coöperate fully with the technician.

Because of the above reasons the findings and standards presented here are submitted as a preliminary survey only; it is believed that they may be of some interest.

The age-frequency distribution of the group is shown in fig. 1, and shows that the modal class for age is from 18 to 20 years, with the mean age of 19 years for the female university students. The graph also indicates that the female students have a narrower range of age than the university males, for the former between 17 and 27 years and for the latter between 14 and 33 years.

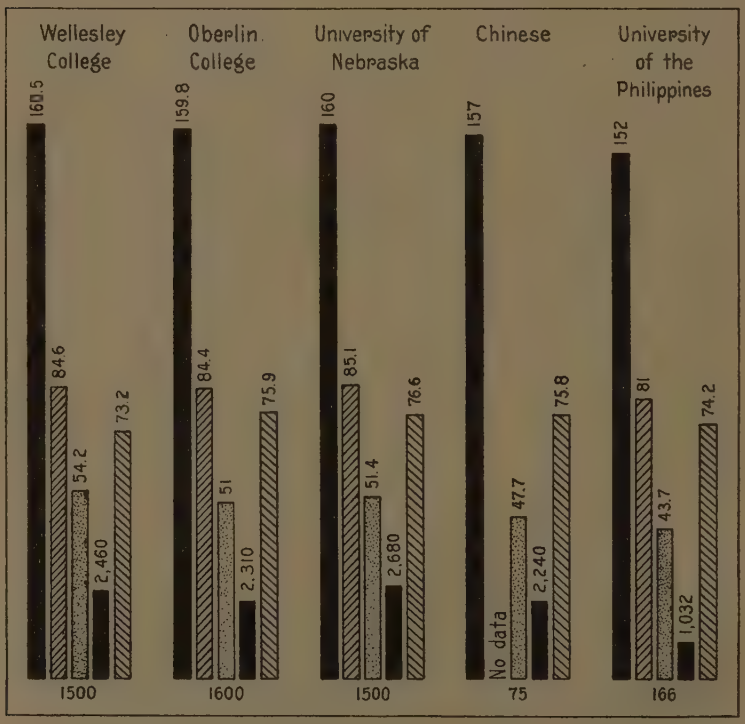

FIG. 3. Graphic comparison of physical measurements of several college groups (female).

STATURE

The mean stature found for the university females is 152.2 centimeters. The modal class for stature is between 150 and 156 centimeters, with a group comprising a little over 51 per

cent of the individuals. The standard deviation existing for stature is 4.69 centimeters. It appears that this record verifies the common admission that Filipino females are lower in stature than their sisters in the American universities. The comparative standing between the standard of American college women and that of our own in stature is shown in Table 19; see also fig. 3.

TABLE 19.—*Comparison of stature of university women.*

	cm.
Wellesley College	160.5
Oberlin College	159.8
University of Nebraska	160.0
University of the Philippines	152.2

According to Table 19, the height of Filipino college women is around 5 per cent lower than that of American college women. We were unable to compare this measurement with that of female students of European universities and colleges, as we could find no literature pertaining to this subject in the local libraries. Comparison with the records on stature for Chinese women shows that the Filipino standard is lower than theirs, which is recorded as 157 centimeters. We failed to find standard data on the Japanese or other oriental races with which to compare the Philippine.

BODY WEIGHT

The average body weight found in this group is only 43.2 kilograms. The modal class in weight is between 35 and 45 kilograms, the group comprising 56.2 per cent. The standard deviation for this measurement is 5.42 kilograms.

As in the case of the body weight of male university students, that of the female group is far below the standard body weights of American college women. The difference amounts to around 20 per cent in favor of the Americans. The body weights of female students in the three American colleges referred to above and of those in the University of the Philippines are shown in Table 20. (See also fig. 3.)

TABLE 20.—*Comparison of body weights of university women.*

College group.	Body weight.	Difference.
	kg.	*P. ct.*
Wellesley College	54.2	24.0
Oberlin College	51.0	16.7
University of Nebraska	51.4	17.6
University of the Philippines	43.2	

It is obvious that there exists a considerable difference in the fall of both stature and weight from the corresponding standards of foreign college groups. Whereas the difference in stature is only around 5 per cent, that of body weight is around 20 per cent in favor of the Americans. The ratio of weight to stature or the body weight per unit stature in our group amounts to only 287.1 grams (per centimeter of stature), whereas that of the American college women amounts to a little more than 325 grams. There exists therefore a difference of about 38 grams per centimeter of stature. The weights per unit stature of Wellesley, Oberlin, and Nebraska are, respectively, 337.6, 319.1, and 321.2 grams.

The lower degree of body weight in the male and female groups of Filipino university students indicates that there must be present some generalized factor or factors that influence the condition of nutrition of the latter.

BUILD

Build is defined in the first part of this paper as the weight of the body in relation to stature or, more definitely, it is the weight multiplied by 1,000 and divided by the square of the stature. It offers one of the most important indices of the physical condition of individuals or groups of people. We found the relative standing of the build of the various college groups to be as indicated in Table 21.

TABLE 21.—*Comparison of build of university women.*

Wellesley	21.2
Oberlin College	20.2
University of Nebraska	20.1
Chinese	19.3
University of the Philippines	18.9

It will be seen from Table 21 that in build the Filipino university women are inferior to Americans and even inferior to Chinese women. We should like to have compared the standard of build of the Filipino group with that of the Japanese and of the different European female groups, but failed to find any literature on the subject with respect to those races. From actual observations on the body condition and size of Japanese women it appears more than likely that in build their standard is higher than is that of Filipino women.

VITAL CAPACITY

In this measurement we believe some questionable errors have occurred in recording, as extraordinary difference and variation

in the interrelation of the vital capacity and the chest circumference were found in the records of individuals. Possibly, the women from whom the measurements were obtained failed to coöperate in making the records for vital capacity, or perhaps they were not properly instructed how to use the spirometer. The clothing was not removed when the chest measurement was being taken and, in the majority of cases, the inspiration and expiration figures in recording the vital capacity were not fully and uniformly registered. Our finding in this regard is given below as a mere exposition of data, and our conclusions are based on surmise and are subject to future checking and verification.

The average vital capacity found for this female group is 1,032 cubic centimeters. The modal class for this measurement is between 900 and 1,020 cubic centimeters, comprising a little over 59 per cent. The standard deviation is 26.5 cubic centimeters.

The vital capacity recorded is found to be much lower than the standard reported for the vital capacity of college women from Wellesley, Oberlin, and University of Nebraska, the records for which are 2,460, 2,310, and 2,680 cubic centimeters, respectively. The differences observed are so obvious that further emphasis does not seem necessary. The Filipino records, compared with the standards of the colleges mentioned, are around 138, 123, and 159 per cent lower. If the Filipino standard is really representative it is certainly regrettable that such poor development and lung expansion exist and are allowed to continue. There is urgent need of remedial measures, and such measures should be instituted at once so that the normal expansion and capacity of the lungs of Filipino women may be increased by regular and properly conducted exercise.

It is, indeed, astonishing that the Filipino standard is much lower also than that of Chinese women. The Chinese standard shows the considerable difference of 117 per cent higher than the Philippine record. The vital-capacity standard of Chinese college women is given as 2,240 cubic centimeters, whereas that of Filipinos is 1,032 cubic centimeters. Even taking for granted that our figures for vital capacity in the work are too low due to lack of coöperation on the part of the subjects and to errors committed in recording the data, we believe that our finding cannot be more than 30 per cent lower than what might have resulted had careful measurements been taken. It seems obvious, therefore, that a low condition of vital capacity in Filipino women is actual.

Various reasons can be given in explanation of this regrettable condition, the most important of which is the lack of properly conducted exercise among Filipino women and their indisposition or indifference to physical exertion of any kind. Some of the other important reasons have already been given in the first part of this paper and, considered collectively, they explain the apparently existing ignorance of the proper method of breathing and, hence, the lack of good expansion of the lungs. It is certainly necessary that breathing exercises be regularly given in conjunction with other prescribed physical exercises in the public schools.

Weakened resistance of the lungs is the usual sequence of the existence of low vital capacity and will certainly promote the rapid course of pulmonary tuberculosis. The question of vital capacity is, indeed, of paramount importance in the Philippines, in regard to both young men and young women, because of its direct relation to the very serious question of high morbidity and mortality due to pulmonary tuberculosis among young Filipinos.

CHEST CIRCUMFERENCE

In this measurement also we believe there has been considerable error, either in the method of measurement or in the way of recording the data. Our findings do not seem to agree with our common observation, nor with the comparative standing of our group with the records of the college groups referred to. Our average chest circumference is 74.2 centimeters There is presented a modal class of between 74 and 78 centimeters chest circumference in the group and the standard deviation found amounts to 3.66 centimeters.

The above record compared with the standard chest circumference of the women of the colleges referred to shows close similarity in the size of the chest. The comparative standing of the groups is shown in Table 22. (See also fig. 3.)

TABLE 22.—*Comparison of chest measurement of university women.*

	cm
Wellesley	73.2
Oberlin	75.9
University of Nebraska	76.6
University of the Philippines	74.2

It is difficult to believe that the chest circumference of Filipino college women, as indicated in Table 22, is almost as great as that of American college women when their average vital capacity is less than half that of the American groups. We cannot explain this great difference between the chest circumference

and the lung contents; possibly greater development of the breast is natural in a tropical region, or perhaps the methods of recording vital capacity and of measuring the chest circumference in our group were irregular and incorrect. We learned that, in taking the chest circumference of the women of the University, the clothing was not removed and that many points essential to correct registration of data were taken for granted. In most cases due care was not observed to see that the tape was closely adapted to the thorax and mamma or that it bridged any part of the clothing. Therefore, indications point to the fact that our figures for chest circumference of the female group are too large. Therefore, the record and the standard derived from it as given here lose the greater part of their value and should be checked and verified later by new measurements.

It does not seem proper to report on the index of constitution, or robustness, of the female group under study, as this index depends upon the relation of stature, weight, and chest circumference. The last-mentioned measurement being more or less unreliable, the result of such a computation will necessarily be of little value.

SUMMARY OF FINDINGS IN THE FEMALE GROUP

Table 23 and fig. 3 present in concise manner our findings on the physical measurements of the female students of the University of the Philippines. Due allowance must be made in regard to the standard for the vital capacity and chest circumference, as already explained in previous paragraphs.

TABLE 23.—*Summary of measurements of Filipino university women.*

Measurement.	Mean.	Modal class.	Standard deviation.
Stature.....cm..	152.2	150– 156	4.69
Body weight.....kg..	43.2	35– 45	5.42
Vital capacity.....cc..	1,032.0	900–1,020	26.50
Chest circumference.....cm..	74.2	74– 78	3.66
Sitting height.....cm..	81.0	80– 84	2.88

The body-weight-per-unit stature in this group (per centimeter of stature) amounts to 287.1 grams The standard of build is only 18.9 points.

For the purpose of comparative study Table 24 is given, which shows the physical standards of women students at some of the American colleges in comparison with those encountered in our work for women students of the University of the Philippines.

TABLE 24.—*Comparative measurements of university women.*

College group.	Stature.	Body Weight.	Weight-per-unit-stature.	Build.	Vital capacity.	Chest circumference.
	cm.	*kg.*	*g.*		*cc.*	*cc.*
Wellesley College	160.5	54.2	337.6	21.2	2,460	73.2
Oberlin College	159.8	51.0	319.1	20.2	2,310	75.9
University of Nebraska	160.0	51.4	321.2	20.1	2,680	76.6
Chinese College women	157.0	47.7	303.8	19.3	2,240	75.8
University of the Philippines	152.2	43.7	287.1	18.9	1,032	74.2

The figures for the Filipino college women are far below those of college women of America. Our records are even lower than are those of Chinese college women. As in the case of the male students, the female group also shows lower stature and lower body weight, and even much lower vital capacity than do American college women. It is noteworthy that the findings in both the male and the female groups of the Filipino university population, compared with the university population of other countries, demonstrate so low a standing. It would seem that certain general factors exist that influence and affect the physical condition and nutritional development of both groups. These factors have been discussed in the first part of this paper.

One additional point of importance that it is desired to mention here is the question of stimulating young people, and especially the young women, to devote more time and interest to out-door and open-air exercises. There exists great need of properly regulated and supervised exercise and out-door recreation for girls. If it is desired to improve the race in physical build from one generation to another it is very important and necessary that the country's future mothers be made physically fit, not only to ward off disease, but particularly to qualify them for the delicate task of bringing forth healthy and sound children and to nourish such children with the best natural feeding that a sound body constitution can offer.

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ILLUSTRATIONS

TEXT FIGURES

FIG. 1. Age frequency distribution of university students (University of the Philippines).
2. Graphic comparison of physical measurements of several university groups together with those of some oriental races (male).
3. Graphic comparison of physical measurements of several college groups (female).

PHILIPPINE AND OTHER ORIENTAL DROSOPHILIDÆ

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Through the kindness of Prof. M. Bezzi I have been able to study a series of Philippine Drosophilidæ, collected chiefly by Prof. C. F. Baker. I have included in the present paper the results of a study of two other Oriental series in my collection, taken in Formosa by Dr. R. Takahashi and in India by Miss Eleanor D. Mason. Dr. O. Duda has recently published two papers dealing with the Palæarctic and Oriental members of the family, based on a study of much of the material in European museums.[1] These papers are so nearly complete that they must serve as the basis for any study of the Old World species. All that I shall do here is to present a few notes on species that I have seen, correlate the new species here described with Duda's account, add a few observations based on examination of some of the type material at the British Museum (which I visited in 1922), and introduce some modifications in the system, based chiefly on Malloch's work.[2]

The types of the new species based on Philippine material have been returned to Professor Bezzi. The types of *Drosophila* (*Spinulophila*) *immigrans formosana* var. nov. and of *D. takahashii* sp. nov. have been deposited in the American Museum of Natural History. Paratypes are in these two collections and in my own collection.

Genus AMIOTA Loew

Malloch (February, 1924) shows that *Amiota* Loew has priority over *Phortica* Schiner. I formerly placed both names as synonyms of *Stegana* Meigen, but Malloch shows that the genera are easily separable by the thornlike bristles on the undersurface of the costal vein near the wing tip. These thorns are present in

[1] Ann. Hist. Nat. Mus. Hung. 20 (December 24, 1923) 24–59; Arch. Naturg. 90A (June, 1924) 172–259.

[2] Proc. Linn. Soc. N. S. Wales 48 (December 14, 1923) 601–622; 49 (October 24, 1924) 348; Proc. Biol. Soc. Wash. 37 (February 21, 1924) 25–42.

Stegana (and also in *Leucophenga*) but absent in *Amiota*. Duda separates the two forms on the basis of the plane of the long axis of the eye (horizontal in *Stegana*, vertical in *Amiota*). This division does not correspond to that of Malloch, and seems to me less satisfactory, as it places in *Amiota* a number of species that appear to be much more naturally grouped with *Stegana*. The three new forms described here have a bearing on the ultimate treatment of the group; all of them key to Duda's subgenus *Eostegana* (Hendel) of *Amiota*, but two have costal spines while one has not, and the appearance of the forms is so diverse that it seems certain they should be given at least subgeneric distinction. Owing to lack of material I have not attempted here to elaborate any further classification than that into *Stegana* (with costal spines) and *Amiota* (without costal spines).

AMIOTA ALBODORSATA sp. nov.

Female.—Arista broken, but long branches still present above and below. Second orbital minute, inserted at same level as third. Front three times the width of an eye (as viewed from above), narrowed below. Greatest diameter of eye inclined about 45° from the vertical, nearly twice the diameter at right angles to it. Carina large, flat. Antennæ yellowish white, second joint grayish above. Face, front, and occiput white. Cheeks dark brown.

Mesonotum and scutellum white. The mesonotum is badly rubbed in the type; the scutellum is large, being more than half as long as the mesonotum. Pleuræ blackish brown, with a few small grayish markings. Legs dark brown.

Wings blackish, bent down at base as in most species of *Stegana*. Costa to apex of fourth vein, no thorns on its third section. Discal and second basal cells separated by a cross vein. Third vein at tip of wing; third and fourth veins not convergent apically. Second vein bent outward at apex, nearly straight basal to this curve. Last section of fifth vein 1.5 times length of posterior cross vein.

Abdomen yellow, each segment with a posterior black band. Egg guides yellowish brown, long, with black teeth below and a black point posteriorly.

Length, 2.25 millimeters.

Los Baños, Laguna Province, Luzon, Philippine Islands (*C. F. Baker*), type and only specimen.

This species resembles *Stegana* superficially; it might perhaps best be made the type of a new genus intermediate between *Stegana* and *Amiota*.

AMIOTA LEUCOPHENGOIDES sp. nov.

Male.—Arista with about twelve long branches above and eleven short ones below. Antennæ yellowish brown, face and frons yellow with whitish reflections, ocellar dot dark brown. Frons half the width of an eye, its sides nearly parallel. Anterior orbital broken in the type; middle orbital half the size of upper, twice as far from upper as from lower. Only one large vibrissa. Carina distinct, long but low. Cheeks very narrow. Eyes bare, vertical diameter twice horizontal.

Mesonotum and scutellum dark brown, somewhat pollinose posteriorly. Prescutellars large. Pleuræ dark brown, somewhat pollinose. Legs yellowish brown. Mesonotum black.

Wings straight, not broken at base as in typical *Stegana*. Discal and second basal cells separated by a cross vein. Costa reaches only to apex of third vein. No costal thorns such as are present in *Stegana*. Second, third, and fourth veins nearly straight, not sinuate or converging. Wings slightly smoky.

First abdominal segment yellow, with a broad black fascia on each side, the fasciæ not quite meeting in the middorsal line. Remaining abdominal segments shining black, each with a narrow yellow posterior border.

Length, 3 millimeters.

Batbatan Island, Philippine Islands (*R. C. McGregor*), type and only specimen.

This species might be placed in *Leucophenga* if one were disposed to emphasize the short costa rather than the basal cross vein.

Genus STEGANA Meigen

STEGANA BAKERI sp. nov.

Arista with about seven branches above and four below. Carina absent. Antennæ brown, third joint blackish above. Face and mouth parts brown; frons brown, darker above. Frons parallel-sided, two-thirds the width of an eye. Lower and middle orbitals inserted at the same level, lower nearer midline of frons; upper orbital nearer to verticals than to two lower orbitals. Lower and middle orbitals nearly the same size. Postverticals minute. Cheeks very narrow. Vertical diameter of eye $1\frac{2}{3}$ horizontal diameter. Eyes bare.

Prescutellars well developed. Mesonotum reddish brown, subshining. Legs and pleuræ brownish yellow. A minute bristle near lower border of propleura.

Wings bent at base as in typical *Stegana*. Costa to apex of fourth vein; thorns on its underside just before apex of third

vein. Wings slightly smoky anteriorly. Second, third, and fourth veins not sinuate or convergent. Discal and second cells separate.

First abdominal segment yellow anteriorly, with a broad dull black band posterior to this, and a narrow whitish posterior margin. Second segment narrow, bright yellow, with no hairs or bristles. Third segment shining black with a narrow yellow anterior margin. Fourth segment shining black. Fifth segment yellow with black lateral margins.

Length, 3 millimeters.

Mount Maquiling, Luzon, Philippine Islands (*Baker*), type and only specimen.

The straight longitudinal veins of this species suggest *Amiota* or *Leucophenga;* but the characters given place it in *Stegana* as here defined.

LEUCOPHENGA HALTEROPUNCTATA Duda.

Mount Maquiling and Los Baños, Laguna Province, Philippine Islands (*Baker*).

LEUCOPHENGA ARGENTATA de Meijere.

Dapitan, Zamboanga Province, Mindanao, and Los Baños, Laguna Province, Philippine Islands (*Baker*).

LEUCOPHENGA BEZZII sp. nov.

Arista with about nine branches above and four below. Antennæ yellow, third joint brown. Face, mouth parts, and frons brownish yellow. Frons parallel-sided, nearly as wide as an eye. Lower orbital inserted scarcely below middle one, but nearer midline. Middle orbital slightly larger than lower one. Upper orbital slightly nearer to inner vertical than to middle orbital. Postverticals minute. Carina absent. Cheeks very narrow.

Prescutellars well developed. Mesonotum and scutellum reddish brown, lightly pollinose. Pleuræ and legs yellow. Halteres whitish.

Wings smoky. Costa to apex of third vein. Tubercles on underside of costa just before apex of third vein.

First abdominal segment yellow, with a broad black fascia on each side, the fasciæ almost meeting in the middle line in one specimen. Second and third segments black, with yellow anterior border that is narrower in the median dorsal region. Fourth segment black. Fifth segment yellow, with black lateral margins.

Length, 2.5 millimeters.

Mount Maquiling, Luzon, Philippine Islands (*Baker*), type and paratype.

Genus ZAPRIONUS Duda

Subgenus PHORTICELLA Duda

Phorticella Duda (type, *Drosophila bistriata* de Meijere) was based on the small second orbital, four acrostichal rows, and absence of femoral tubercles. The two new species here described have new combinations of these characters, so that it seems most convenient to reduce *Phorticella* to a subgenus of *Zaprionus*, basing it on the small second orbital alone. Duda's definition of the genus *Zaprionus* should also be modified slightly so as to include the neotropical *Z. orbitalis* (Sturtevant), which has grayish orbits and no thoracic stripes. This species and *Z. bilineata* (Williston) from the West Indies, as well as *Z. multistriata* sp. nov., belong to the typical subgenus; *Z. bakeri* sp. nov. belongs to *Phorticella; Z. albicornis* Enderlein[3] from Formosa and *Z. lineosa* (Walker) probably belong to the subgenus *Zaprionus*, but need to be checked.

ZAPRIONUS LINEOSA (Walker).[4]

From Macassar, Celebes. The type is a *Zaprionus*, with the usual brownish red color of the genus; four mesonotal white stripes (besides the notopleural stripes), that are barely united anteriorly into two; arista with three branches above and two below; face white.

ZAPRIONUS MULTISTRIATA sp. nov.

Female.—Arista with about four branches above and two below. Middle orbital very slightly smaller than upper, inserted halfway between upper and lower. Face prominent, carina large and flat. Frons yellowish red; orbits, median stripe, and lateral margins of ocellar triangle silvery white. Face, cheeks, and antennæ yellowish brown. Greatest width of cheeks (at lower posterior corner of head) about one-fourth height of eye. Eyes pilose. Only one prominent oral bristle.

Acrostichal hairs in six rows. Mesonotum reddish, with nine longitudinal white stripes, one between the two median acrostichal rows and four on each side as follows: One between the two outer acrostichal rows (that is, separated from the median stripe by two rows of acrostichal hairs); one outside the dorsocentral row and appearing continuous with the orbital

[3] Deutsch. Ent. Zeit. (1922) 295.

[4] Proc. Linn. Soc. London 4 (1860) 170, as *Notiphila*.

stripe and with the scutellar margin; an interrupted stripe appearing as a white margin to the humerus; and a stripe posterior to the suture. Scutellum reddish; with a median and two lateral white stripes that are continuous with the mesonotal stripes. Legs and pleuræ yellow. No femoral tubercles present.

Wings clear, veins brownish. Second, third, and fourth veins straight.

Abdomen dull yellowish brown.

Length, 2.5 millimeters.

Mount Maquiling, Luzon, Philippine Islands (*Baker 5260*), type and only specimen.

ZAPRIONUS (PHORTICELLA) BAKERI sp. nov.

Male.—Arista with about six branches above and four below. Middle orbital scarcely one-fourth the other two. Face prominent, carina large and flat. Face yellow. Frons yellowish red, orbits silvery white, forming white stripes which extend over the outer surfaces of second antennal joints. Only one prominent oral bristle. Greatest width of cheek about one-eighth greatest diameter of eye. Eyes pilose.

Acrostichal hairs in six rows. Mesonotum yellowish red, with four white longitudinal stripes, two on each side as follows: One just outside the dorsocentral row and appearing as a continuation of the orbital stripes, and a less distinct one just above the notopleural suture. On each side of the more-distinct white stripe is a darker brownish red stripe; the dorsocentral row of hairs is in the inner of these dark stripes. Scutellum yellowish red, bordered by white stripes that are continuations of the conspicuous mesonotal stripes and are also in turn margined by dark brownish red stripes. Pleuræ and legs yellow. No femoral tubercles.

Wings clear, veins brown. Last section of fifth vein $1\frac{2}{3}$ the length of posterior crossvein.

Abdomen yellowish brown, each hair and bristle arising from a dark brown spot.

Length, 2.5 millimeters.

Mount Maquiling, Luzon, Philippine Islands (*Baker 6230*), type and only specimen.

Genus DROSOPHILA Duda

Duda has separated *Drosophila* into a number of subgenera; and Malloch has suggested that some of his segregates from *Mycodrosophila* should also be placed under *Drosophila*. My opinion is that *Chaetodrosophilella* (see page 367) is also deserving of

only subgeneric rank. *Incisurifrons* Duda is a synonym of *Microdrosophila* Malloch. The three remaining subgenera present in the Oriental material before me were all first published in 1923 as genera, and genotypes have not been designated. We may select the following:

Hirtodrosophila, H. longecrinita Duda.
Paradrosophila, Drosophila pictipennis Kertesz.
Spinulophila, S. signata Duda.

In the case of *Spinulophila* only three forms were included, and two of these were described chiefly by stating their differences from *S. albomicans* Duda; but that species seems to have been undescribed at the time and therefore cannot become the genotype.

DROSOPHILA (CHAETODROSOPHILELLA) QUADRILINEATA de Meijere.

Mount Maquiling, Philippine Islands (*Baker*), one specimen. Recorded from Java and Annam. Duda gives the name as *Chaetodrosophila* in 1924; I have followed the original spelling.

DROSOPHILA (HIRTODROSOPHILA) LONGECRINITA Duda (typical form).

"Culasi, Panay. 5.18.18. Hillside forest at 800 meters. On fungus." (*McGregor*), seven specimens. Described from Formosa.

The six Oriental forms of the subgenus *Spinulophila* before me can be separated by the following key:

Key to six Oriental forms of Spinulophila Duda.

1. Cheeks (at lower posterior corner of head) one-fourth height of eye.. 2.
   Cheeks one-sixth to one-tenth height of eye..... 3.
2. Males, basal tarsal joint of first leg with no strikingly long hairs.
   D. (S.) immigrans Sturtevant.
   Males, basal tarsal joint of first leg with strikingly long hairs.
   D. (S.) immigrans var. formosana var. nov.
3. Thorax metallic; abdomen shining metallic black.
   D. (S.) monochaeta sp. nov.
   Thorax reddish; abdomen without bands; 3 millimeters long.
   D. (S.) rubra sp. nov.
   Thorax yellow, not reddish; abdomen with black bands; or fly less than 2 millimeters long..... 4.
4. Males with conspicuous silvering on front; less than 2 millimeters long; abdominal bands narrow or absent..... **D. (S.) nasuta Lamb.**
   Faint silvering on front; more than 2 millimeters long; black abdominal bands distinct, broader in middorsal line....**D. (S.) balneorum sp. nov.**

DROSOPHILA (SPINULOPHILA) IMMIGRANS Sturtevant.

Drosophila tripunctata of authors, not of Loew.
Drosophila cilifemur VILLENEUVE.
Drosophila hypocausta OSTEN SACKEN?

I have the typical form of this species from Taihoku, Formosa (*R. Takahashi*), and females that are presumably typical (the variety *formosana* is not identifiable in females) from Kodaikanal, Madras, India (*E. D. Mason*). The species is recorded from Europe, the Canary Islands, the United States, Costa Rica, Hawaii, Australia, and Formosa. *Drosophila hypocausta* Osten Sacken, which is perhaps an earlier name for the species, was described from the Philippine Islands.

DROSOPHILA (SPINULOPHILA) IMMIGRANS FORMOSANA var. nov.

Male.—Differs from typical *immigrans* only in the front tarsi. The short dense hairs of the two basal joints are less conspicuous than in the typical form, but there is a series of much longer recurved black hairs on the outer and anterior surfaces of all the joints of the front tarsi.

I am unable to separate the female from the typical form.

Taihoku, Formosa, March, 1924 (*Takahashi*), type and seven paratype males.

Duda also recognized this form from Formosa, but he failed to give it a name.

DROSOPHILA (SPINULOPHILA) MONOCHAETA sp. nov.

Arista with about eight branches above and five below. Carina prominent, large, flat. Middle orbital minute, but larger than the hairs anterior to it. Only one prominent oral bristle. Greatest width of cheek about one-sixth height of eye. Front reddish yellow; face, cheeks, and mouth parts yellow.

Mesonotum dark reddish brown, shining, with metallic bluish reflections posteriorly. Scutellum, pleuræ, and coxæ shining dark reddish brown. Legs yellow. Front femora somewhat swollen, bearing the usual row of small spines and, on the undersurface, only one bristle, which is much longer and stronger than the bristles usually present here.

Wings clear, except extreme base which is darkened. Only one spine at apex of first costal section. Costal index about 5, fourth vein index about 1.1, 5x index about 1, 4c index about 0.4.

Abdomen shining metallic black; two basal segments bluish, third to fifth more coppery.

Length, 2.5 millimeters.

Mount Maquiling, Luzon, Philippine Islands (*Baker 6224*), type and only specimen.

The metallic thorax and abdomen and the single long bristle on the undersurface of the front femur will identify this species.

DROSOPHILA (SPINULOPHILA) RUBRA sp. nov.

Male.—Arista with about eight branches above and four below. Carina large and flat. Second oral bristle nearly as large as first. Middle orbital not larger than the minute reclinate hairs anterior to it. Front and antennæ yellowish red. Face, cheeks, and mouth parts yellow. Greatest width of cheek about one-eighth height of eye.

Acrostichal hairs in eight rows. Mesonotum and scutellum dull yellowish red, pleuræ paler. Legs yellow. The usual row of spines present on front femora. Front tarsi without special hairs or bristles.

Wings clear, veins brown. Only one large bristle at apex of first section of costa. Costal index about 4, fourth vein index about 1.1, 5x index about 0.9, 4c index about 0.6.

Abdomen dull yellowish red.

Length, 3 millimeters.

Mount Maquiling, Luzon, Philippine Islands (*Baker*), type and only specimen.

The large size and red color should serve to identify this species easily.

DROSOPHILA (SPINULOPHILA) NASUTA Lamb.

Drosophila albomicans DUDA.

Taihoku, Formosa (*Takahashi*).

Recorded from the Seychelles and from Formosa. Lamb does not mention the femoral spines characteristic of *Spinulophila* in the description of *nasuta;* but I have seen the type, and such spines are present. The synonymy given here needs no further explanation.

DROSOPHILA (SPINULOPHILA) BALNEORUM sp. nov.

Male.—Arista with about seven branches above and five below. Carina large and flat. Second oral bristle nearly as large as first. Middle orbital one-fourth size of the other two. Greatest width of cheek one-sixth height of eye. Head yellowish brown, ocellar dot blackish, front with slight whitish reflection.

Mesonotum yellowish brown, slightly grayish pollinose. Scutellum and pleuræ brown. Legs brownish yellow, front femora darker. The usual row of spines on front femora; front tarsi plain.

Only one large bristle at apex of first costal section. Wings clear, cross veins faintly clouded. Costal index 3.5; fourth vein index 1.3; 5x index 1; 4c index 1.7.

Abdomen yellowish brown, each segment with a dark posterior band.

Length, 2.5 millimeters.

The females before me have paler legs and long slender egg guides.

Los Baños, Laguna Province, Luzon (*Baker 984*), type. Los Baños, Mount Maquiling, Philippine Islands (*Baker*) paratypes, three females.

DROSOPHILA (PARADROSOPHILA) LURIDA Walker.

Discomyza punctipennis v. d. WULP.

Mount Maquiling, Luzon, Philippine Islands (*Baker*), two specimens.

I have examined the type (from Macassar, Celebes), and a Javan specimen determined by de Meijere. These agree with each other and with the Philippine specimens.

DROSOPHILA (PARADROSOPHILA) ACUTA sp. nov.

Female.—Arista with about ten branches above and four below. Second oral nearly as long as first. Middle orbital one-third other two. Carina large, broad, and flat. Second antennal joint with an unusually long and heavy bristle on its inner surface. Front dark reddish brown, a silvery spot on the occiput on each side of the ocellar region. Face black, cheeks dark brown. Greatest width of cheek about one-fourth height of eye. Eyes pilose.

Prescutellars large. Acrostichal hairs in at least eight rows. Thorax dull black. Legs brown, front femora blackish, all tarsi yellowish. Halteres white.

Wings clear, blackish at base. Costal index about 1.8; fourth vein index about 1.8; 5x index about 0.9; 4c index about 1.4.

Abdomen dull black. Egg guides brown, slender, drawn out into an acute tip.

Length, 2.7 millimeters.

Mount Maquiling, Luzon, Philippine Islands (*Baker*), type and only specimen.

DROSOPHILA MELANOGASTER Meigen.

Drosophila ampelophila LOEW.

Nungambaukam, Madras, India (*Mason*).

I also have specimens from Peking, China, and from Fukuoka and Shinano, Japan. The species is cosmopolitan. Duda argues that Loew's name should be used, but I am not convinced.

DROSOPHILA ANANASSAE Doleschall.

Nungambaukam, Madras, India (*Mason*), many specimens of both sexes. One of the females has an egg just protruding from the ovipositor; this egg has two anterior filaments.

The species is recorded from Formosa, Java, Sumatra, and New Guinea.

DROSOPHILA TAKAHASHII sp. nov.

Male.—Arista with about five branches above and four below. Second oral nearly as long as first. Middle orbital one-fourth the other two. Carina low, flat. Front, antennæ, face, and cheeks brownish yellow. Greatest width of cheek about one-tenth height of eye. Eyes pilose.

Acrostichal hairs in eight rows; no prescutellars. Mesonotum and scutellum yellowish red, subshining. Pleuræ and legs yellow. On the undersurface of the basal joint of the front tarsi are short stiff black bristles, arranged in six short transverse rows; two such rows also on the undersurface of the second joint of the front tarsi.

Wings clear. Costal index about 2.3; fourth vein index about 2.6; 5x index about 2; 4c index about 1.3.

Abdomen shining black, each of the three basal segments with a basal yellowish band.

Length, 2 millimeters.

The females agree with the above description, except that the front tarsi are plain and the fourth abdominal segment has a basal yellow band.

Taihoku, Formosa, March, 1924 (*Takahashi*), type and nineteen paratypes.

The species resembles *D. melanogaster* and *D. ananassae.* The cheeks are narrower in *takahashii,* and the structure of the male front tarsi is different. In *melanogaster* the small black bristles are confined to one diagonal row on the inner dorsal surface of the basal joint; in *ananassae* there are several transverse rows on the ventral surface, but the bristles are yellowish instead of black.

DROSOPHILA MONTIUM de Meijere var. ATROPYGA Duda.

Nungambaukam, Madras, India (*Mason*), one male.

DROSOPHILA TRISTIPENNIS Duda.

Nungambaukam, Madras, India (*Mason*), one male.

DROSOPHILA HYDEI Sturtevant.

Taihoku, Formosa, March, 1924 (*Takahashi*), one specimen.

Recorded by Malloch from Sydney, Australia, and occurs from Massachusetts to California, Panama, and Porto Rico. It is distinguishable from *D. repleta* in that it has smaller eyes and no lateral pale spots on the dark abdominal bands.

DROSOPHILA HIRTISCUTELLATA sp. nov.

Male.—Arista with five branches above and three below. Only one prominent oral bristle. Middle orbital one-third the other two. Head dark brown. Greatest width of cheek one-sixth height of eye. Eyes pilose.

Thorax and legs dark dull brown, tarsi yellowish. Margin of scutellum with a few hairs; about three in front of anterior scutellar bristle and three behind it.

Wings clear. Costal index about 2; fourth vein index about 2; 5x index about 1.3; 4c index about 1.2.

Basal abdominal segment brown, with dark fascia on each side; remaining segments dark dull brown, each with a narrow apical border that is paler.

Length, 2.2 millimeters.

Mount Maquiling, Luzon, Philippine Islands (*Baker*), type and only specimen.

The hairs on the scutellum will serve to identify this species. The character is not known in any other member of the family, if one excludes the genus *Curtonotum* and its relatives from the Drosophilidæ (as I am inclined to do).

DROSOPHILA ELONGATA sp. nov.

Male.—Arista with about six branches above and three below. Only one prominent oral bristle. Middle orbital hairlike. Carina low, broad, flat. Front shining yellow. Face whitish. Antennæ and cheeks yellow. Greatest width of cheek one-sixth height of eye. Eyes bare. Head bristles all brown.

Acrostichal hairs in eight rows. Prescutellar region damaged in the type. Mesonotum and scutellum shining yellow. Pleuræ and legs yellow. First tarsal joint of front leg as long as the four distal joints. Thoracic bristles and hairs all yellowish.

Costal, marginal, and apex of submarginal cells black; wings otherwise clear. Distal costal incision well marked. Costal index about 1.5; 5x index about 1.1; 4c index about 1.

Abdomen elongate; shining yellow above, shining black laterally, dull yellow below; bristles yellow.

Length, 2.7 millimeters.

Los Baños, Laguna Province, Luzon, Philippine Islands (*Baker*), type and only specimen.

This species is scarcely a *Drosophila*, the bare eyes and elongate abdomen being distinctly out of place here. Perhaps it is a member of one of the groups placed by Duda near *Mycodrosophila*, but I am unable to satisfy myself as to the status of these forms without more material than is now available. Malloch has previously expressed doubts as to the treatment that should be accorded to this general group.

NOTES ON TYPE SPECIMENS OF ORIENTAL DROSOPHILIDÆ DESCRIBED BY WALKER

DROSOPHILA FINIGUTTA Walker.

Drosophila finigutta WALKER, Proc. Linn. Soc. 3 (1859) 126, Aroe.

This is a sapromyzid.

DROSOPHILA ILLATA Walker.

Drosophila illata WALKER, Proc. Linn. Soc. 4 (1860) 168, Macassar, Celebes.

This is a *Drosophila*, of the *melanogaster* group; but the type is so badly damaged that specific identification will probably not be possible.

DROSOPHILA LATERALIS Walker.

Drosophila rudis WALKER, Proc. Linn. Soc. 4 (1860) 169, Macassar, Celebes.

A *Leucophenga*, apparently near *L. salatigae* de Meijere.

DROSOPHILA LURIDA Walker.

Drosophila lateralis WALKER, Proc. Linn. Soc. 4 (1860) 169, Macassar, Celebes.

See above, under subgenus *Paradrosophila*.

DROSOPHILA MELANOSPILA Walker.

Drosophila melanospila WALKER, Proc. Linn. Soc. 3 (1859) 126, Aroe.

This is a sapromyzid.

DROSOPHILA PINGUIS Walker.

Drosophila pinguis WALKER, Proc. Linn. Soc. 8 (1865) 168, New Guinea.

This is a sapromyzid.

DROSOPHILA RUDIS Walker.

Drosophila rudis WALKER, Proc. Linn. Soc. 4 (1860) 168, Macassar, Celebes.

A *Leucophenga,* apparently not recognized since Walker's time. Walker's description of the wing pattern is accurate and should serve to identify the species. The palpi are yellow.

DROSOPHILA SOLENNIS Walker.

Drosophila solennis WALKER, Proc. Linn. Soc. 4 (1860) 168, Macassar, Celebes.

This is a true *Drosophila.* I have seen no other specimens agreeing with it, but Duda's table suggests that it may be the same as *D. obscuricornis* (de Meijere). The species suggests *D. immigrans,* but lacks the femoral spines of *Spinulophila.* The middle orbital is nearly two-thirds the length of the upper one; second oral nearly as long as first; carina large and flat; acrostichal hairs in eight rows; four dark stripes on mesonotum, the outer ones interrupted; costal index about 3.6, fourth vein index about 1.5, 5x index about 1.1, 4c index about 0.7; abdomen yellow, each segment with a broad posterior dark brown band that is broader in the median dorsal line.

NOTIPHILA LINEOSA Walker.

Notiphila lineosa WALKER, Proc. Linn. Soc. 4 (1860) 170, Macassar, Celebes.

This is a *Zaprionus,* and is included in the discussion of that genus presented in this paper.

SCIOMYZA LEUCOMELANA Walker.

Sciomyza leucomelana WALKER, Proc. Linn. Soc. 4 (1860) 144, Macassar, Celebes.

As was pointed out to me by Maj. E. E. Austen, this belongs to the genus *Stegana,* as here understood.

BIOLOGY OF THE LARGE PHILIPPINE FOREST SCORPION

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FOUR PLATES

The large forest scorpion *Palamnaeus longimanus* Herbst is rather common on certain islands of the Philippines but, strangely enough, it seems to be absent on other islands of the group, particularly Luzon. During the last twenty years certainly sufficient collecting has been carried on in Luzon to have revealed this species if it were present at all. Our records show the species from various localities in Mindanao, Palawan and, lately, from Tawitawi in the Sulu group.

Although several authors have on various occasions identified Mindanao specimens of this large forest scorpion as *P. longimanus,* the correctness of this identification seems open to doubt, due to the following facts. In the course of the work on the biology of these scorpions it occurred to me that even in the comparatively young stage it should be possible to distinguish males from females, since in *longimanus* the male has rather long and slender chelipeds and in the female they are much stouter, shorter, and broader. Since I was unable to find any appreciable difference in this respect in the different individuals which I raised, I examined over one hundred fifty specimens of alcoholic material in our collection, and to my astonishment found not a single specimen that could be recognized as male by the long chelipeds.

A few Mindanao specimens were examined by Professor Borelli of Turin, and determined by him as *P. longimanus* females and, in a letter recently received from him, he states, "the females of *P. longimanus* and of *P. oatesii* are very difficult to distinguish."

From the above-mentioned facts, I am inclined to the belief that the large Mindanao forest scorpion may possibly not be *P. longimanus* Herbst but *P. oatesii* Pocock or a subspecies of the latter since in *oatesii* the two sexes, according to the descrip-

tion, are very much alike, particularly with reference to size and form of the chelipeds. The question can only be solved by anatomical examination of freshly killed material. Since I have at the present time none available, this question must be left open for the present.

The Philippine forest scorpions are usually found in old or virgin forest under the loose bark of dead standing trees, under decaying trunks of trees and logs, or in cavities of rotten stumps located in the jungle, mostly in rather humid and damp places. In most instances I found two or more individuals together in one place, either two adults (which I assumed to be a male and a female) or, more commonly, one adult female and from five to nine young ones. The latter in every instance had gone through at least the third molt. It would seem that in nature the pregnant female selects the most secluded and protected places for giving birth to her offspring, and probably remains in such places until the young have passed the early stages of life. Later, probably impelled by relative scarcity of food, the mother scorpion, followed by her young ones, seeks other hiding places, such as mentioned above, in which they are most commonly found. It is probable that, during the early stages, a relatively large number of the young scorpions fall prey to their enemies. So far I have been unable to ascertain what these enemies are, but very strongly suspect that large geckos, toads, and certain shrews attack young scorpions.

The food of the forest scorpion here dealt with consists of such insects as are found or seek shelter in the places indicated above. In other words, scorpions do not go to seek their food but the insects which serve as their food come to the scorpion's lair for the purpose of hiding. On several occasions I found in a scorpion cavity under a rotten log a few fragments of wings and legs of the large wood cockroach. Various species of Blattidæ seem to be the favored food of this species of scorpion, as I was able to prove in my breeding experiments described later. Of course, other insects which trespass within the bounds of the scorpion's home, such as certain crickets (Gryllidæ), earwigs (Forficulidæ), and certain larvæ of Coleoptera, are also taken at times, but the principal food consists of Blattidæ. From actual observation over a long period of time I can safely state that the amount of food taken by a scorpion depends on the supply that nature provides. If the supply of the proper kind of food is plentiful, at least with reference to the species dealt

with herein, the quantity consumed by the scorpion is relatively very large, contrary to the observations of J. H. Fabre.[1]

On June 15, 1925, I received a large adult living scorpion from Malangas, Mindanao. From its appearance, I concluded that it was probably a pregnant female. Although it had received rather rough treatment on the voyage to Manila, it appeared in healthy condition and fighting spirits. Since so little is known concerning the biology of the scorpions of this region, I seized this opportunity to work out the life history, although somewhat hesitant on recalling the writings of Fabre [2] and his assertion that the life history of the European species is at least five years.

The scorpion was placed in a square museum jar, 8 by 9 by 9 inches. In the bottom of the jar about 1 inch of fine, slightly moist river sand was put and, on top of this, several pieces of convexly curved bark were placed so as to provide a hiding place for the scorpion. The scorpion during the first few days was mostly in hiding during the daytime under the bark in a resting position. The legs and chelipeds were drawn up close to the body and the tail curved flat over the back. Toward evening and at night it would wander around and investigate its surroundings, at times trying to crawl up the sides of the glass container. Very soon I noticed that the scorpion very much disliked the bright daylight and especially the direct sunlight, and always sought the darkest spot of the jar. Accordingly, the jar was placed in a rather dark corner of my work room. On several occasions during the daytime I noticed that the scorpion was rather restless, reaching about with its chelipeds. Since the glass jar was only covered with fine wire gauze, the sand in the jar soon became dry. For that reason, I was inclined to ascribe the restlessness of the scorpion to thirst and tried sprinkling it with water. My supposition proved absolutely correct. The scorpion had to be given a certain amount of water every day, and it was astonishing how long and what large amounts of water this creature would drink. The process of drinking was mostly accomplished by the mandibles taking up the water from grooves in the bark on which the scorpion was sitting at the time, or the mandibles would take up drops of water which were scattered over the different reachable parts

[1] The Life of the Scorpion (English edition) 1923.
[2] Op. cit. page 47.

of its legs. On several other occasions I noticed a very peculiar way of taking up water, absolutely the same as the method I have observed among certain crabs. The scorpion would sip with the mandibles water that had accumulated between the chelæ; that is, it would move the latter close to the mandibles in the way a man holds a glass in his hand and brings it toward his mouth. The scorpion, even when apparently in a sleepy condition and resting quietly in the jar, was at all times very alert; any unusual whiff of air, a slight knock against the jar, or the touching of the bark in the jar would instantly arouse it to assume a combative attitude. The legs would be more spread, the chelipeds would be held with the chelæ in a half-open position, forward or directed slightly upward, and the tail would be raised ready to strike. It is astonishing how quickly it can turn about if the need arises.

The question of food caused considerable worry at first. I tried out various kinds of insects, such as small Locustidæ, Acrididæ, Gryllidæ, and Blattidæ. Besides insects, I also offered specimens of a small species of snail, which is usually found under moist bark, and some earthworms. The scorpion manifested absolutely no gustatory interest in the last-mentioned creatures; but, if an earthworm happened to come too close, it would squeeze the worm with its chelæ, simply as a means of getting rid of the undesirable visitor and starting it to move in another direction.

Of the various insects mentioned above which I offered as food to the scorpion in captivity, only certain small Gryllidæ and all species of Blattidæ were taken by it freely and of its own accord. As mentioned before, the food of the scorpion consists of such insects which, as a matter of chance, come within its reach, and it seems almost as if its chelæ were especially constructed for or particularly adapted to holding such flat insects as Blattidæ. The hungry scorpion is very alert and a cockroach passing over its body or in front near the chelipeds, apparently not being aware of its enemy, is easily caught. It is astonishing to see how quickly a scorpion is able to catch a large cockroach such as *Rhyparobia maderae* Fabricius or *Periplaneta americana* Linnæus, and hold it somewhat above the ground thus preventing the struggling cockroach from getting a foothold by which it would be able to exert more strength in the efforts to free itself from its enemy. During the long period of observation, I have never seen the scorpion use its poisonous stinger at any time in procuring or subduing the

insects serving as its food. I believe the poisonous stinger is used only as a defensive weapon against its enemies. Furthermore, the stinger is certainly not at all well adapted for use on insects, since it is not strong enough to penetrate chitin of ordinary thickness and will glance off readily.

On July 25, at 7 o'clock in the morning, I observed that the scorpion had during the previous night given birth to eleven young ones. Eight of the latter were located on the back of the mother, and three others were suspended from or clinging to the forelegs on the underside of the body.

While I was watching the scorpion, which held its body in a peculiar position, somewhat raised and bent or curved in the middle into a convex shape but with the chelipeds drawn up close to the body (in an aspect from which it appeared as if she exerted some pressure), I noticed that another young scorpion was just in the act of being born. This young one was coming out of the vaginal orifice in the shape of an elongate white drop. No legs or other appendages were visible to me at the time. Unfortunately, I had great difficulty in seeing clearly what was going on through the sides of the thick glass and I did not dare disturb the mother while in the process of giving birth. At any rate, from my short observation I am unable to confirm or to disprove the assertion made by Fabre that the young scorpions are born in a kind of chorion similar to that enveloping certain mammals, and that the female ruptures the sac and liberates the young ones. After a very short time I noticed that the last-born young scorpion was resting on the apical parts of the bent-under forelegs of the mother, slowly making its way up the leg and the sides of her body. The newly born seem to be extremely helpless and frail creatures. During the act of birth I observed also that the pectines were carried in a vertical position pointing downward, seemingly to serve as holders or braces. The young scorpions are extremely sluggish, plump, and fat looking, and very pale, glossy, creamy white. About half an hour after being born the eyes of the young (that is, the two discal eyes as well as the 2×3 frontal-marginal eyes) turned blackish. At about 9 o'clock in the morning all of the young were located on the back of the mother. It took, by actual observation, at least two hours for the last-born young one to locate itself at the final resting place on the back of the mother. During that same day I observed the mother scorpion and her young numerous times; mostly she was in a resting position, but at the same time she was un-

usually nervous and alert to the slightest whiff of air or the slightest disturbance. In the afternoon a photograph of the mother and her young ones was taken; the result was not very favorable owing to the nervousness of the mother, but a photograph of a young one which I had carefully isolated from the mother was successful and is here reproduced as Plate 1, fig. 2. Early in the morning of July 26, to my great astonishment I noticed that the female scorpion had given birth to still more young ones during the previous night, the additional number being twenty-two, since under difficulties I was able to count thirty-four young scorpions in all. Although the mode of giving birth to the young at intervals, in this case in two distinct periods with an intervening rest time of at least ten hours, seems strange to me, similar occurrences are rather common among mammals. Nevertheless, I now look upon my findings as probably due to abnormal environmental conditions, at least pending further observation and verification. The female scorpion, until a few days before giving birth, was during most of the daytime hiding under a piece of bark which formed a flattish cavity and which she almost filled. A day or two previous to delivery she changed her habitat, sitting on top of the bark. The cavity under which she had been hiding was entirely too small for her to have gone through the act of giving birth and the change was instinctively made for that reason. Furthermore, in nature, the female scorpion probably goes through this act in a well-protected and sufficiently large cavity, located in a hollow tree or some other obscure place. In such locality it seems reasonable to suppose that the scorpion, once having commenced giving birth, would continue until all had come forth; but, under the artificial environment, this scorpion probably started during the night, while sitting on top of the bark, and when daylight came interrupted the act until darkness set in again during which delivery was completed. Although my interpretation is theoretical, I consider it a logical explanation of the above facts. The mother scorpion with her litter of thirty-four young all bunched and clustered closely over her back is a truly remarkable sight; indeed, may this not account for her nervousness, particularly since the young cover up her discal eyes and sometimes the frontal lateral eyes as well? On the same day I succeeded in taking the excellent photographs shown in Plate 1, fig. 1 (dorsal view) and Plate 4, fig. 2 (ateral view), both natural size. On the same day, I also noticed that some of the

young ones, probably the ones born the previous day, were slightly darker than the rest. On July 28 the young ones appeared smaller and distinctly darker creamy white than on the previous day; in the afternoon of the 28th the color was still more noticeably darker grayish cream and the young appeared slightly shriveled (see Plate 1, fig. 3, photograph taken on July 28) and not so roundish and plump as on the preceding day. On the succeeding days the young ones became still more pale grayish and at all times were almost motionless. Even when I blew lightly upon them they hardly reacted. During all of this time the mother scorpion was not observed to feed during the daytime as she had done prior to giving birth, but later she drank water on several occasions.

The water was sprinkled on the bark on which the mother scorpion was sitting. She was very much annoyed when a few drops of water fell on her back, which caused her as well as the young to show decided discomfort.

On August 3, or eight days after birth, in the early forenoon, I observed that most of the young ones were going through some very lively contortions, bending and wriggling on the back of the mother, and soon I noticed that they were molting for the first time. It is astonishing how the form of the young scorpions had changed from that of the first stage. They appeared much longer and larger, and their chelipeds, legs, and tails were shaped more like those of the mother scorpion; but they were really smaller than when newly born. Plate 1, fig. 4, shows a young scorpion, natural size, one day after the first molt. Its color shortly after molting was very pale glossy gray, which turned slightly darker as the chitin hardened, except the last tail segment (the vesicle), which was whitish. All of the thirty-three young scorpions (one had been placed in alcohol previously) passed through the first molt within twenty-four hours.

Furthermore, the young ones had become much livelier; frequently I observed them rather restlessly changing their positions on the back of the mother, in doing so wriggling their tails freely. Some of the first exuviæ of the young could be seen adhering here and there to the back of the mother. The fine white skins appear as irregularly torn fragments and seemingly serve the young ones as a medium for hanging on to, or catching hold of, the otherwise rather smooth back of the mother. On August 5 I observed that several of the young scorpions were trying to push each other off, and several actually left the back

of the mother and were trying to hide underneath her. On August 6, early in the morning, I observed that more than half of the young ones were sitting in front and around the mother. After the first molting of the young ones I placed several live medium-sized cockroaches in the jar with the scorpions. Some of them were undoubtedly eaten by the mother scorpion during the night; I suspect that the young ones also took part, but I did not actually see them do so. The young scorpions during the second instar do not seem to grow to any appreciable degree. A very noticeable fact during the second instar is that the different individuals are still remarkably uniform in size. During the night from August 9 to 10 more than half of the young scorpions molted the second time and the last one molted on August 12. The skins, or exuviæ, of the second molt were found scattered about in the jar, some freely exposed, some under the bark. In order to demonstrate the individual differences, I have reproduced in natural size exuviæ of the second molt of two individuals, on Plate 1, figs. 5 and 6. By comparing these with fig. 4, it will be seen that fig. 4 shows the hands, or chelipeds, to be slightly larger. This is due to the fact that the scorpion reproduced as fig. 4 was photographed only one day after the first molt and before it had fully hardened; in other words, as the chitin hardens it also shrinks somewhat. In the third instar, after the specimens were fully hardened the young scorpions were darker, grayish brownish; only the vesicle was still grayish white. Up to August 11, or seventeen days after birth, a few of the young scorpions were still sitting on the back of the mother, but from August 12 none of them continued the practice. All of them were by that time more or less scattered about in the jar, some sitting under or around the mother, others hiding under pieces of bark. The young ones by their actions appeared less timid than before. From the last-mentioned date on I observed the young ones many times in the act of feeding in company with the mother during the daytime. The feeding procedure was usually as follows:

Several adult cockroaches were thrown into the jar containing the scorpions. The mother scorpion, who always seemed to be on the qui vive, quickly turned about and grabbed one of the cockroaches with one of her chelipeds, squeezing it at the same time, and then passed it to the other cheliped, and so on back and forth two or three times, until the roach stopped its violent kicking. After a short interval the scorpion mother

proceeded to tear away small pieces of the cockroach with her mandibles and eat them. The cockroach was not dead by any means but struggled more or less during the process. The young scorpions that had been sitting near the old one, as well as others which were hiding under the bark, had been aroused by the disturbance caused by the rushing cockroaches as well as by the moving about of the mother. They soon learned the cause of all the commotion and soon gathered on and about the prey the mother was holding and joined in the meal, particularly after the mother had removed the greater part of the elytra of the roach and thus had exposed the more juicy part of its abdomen. The mother scorpion would stop eating at intervals for several minutes as if to give the young ones a chance to take their meal. One of the most remarkable facts concerning the mother scorpion I noticed many times was the following: If several cockroaches or other insects were rushing about in the jar, sometimes running over or under the mother, the latter invariably noticed the difference between an insect or other strange object touching her and the contact of her own young. She would quickly turn upon the touch of even a small cockroach running over her but would pay no attention to her own young doing the same thing. The latter, particularly during feeding time, climbed over her back, or sat upon the carapace in variable numbers so that her eyes were covered up. The sensitive hairs present on many parts of her body, chelipeds, legs, and tail, seem to be very efficient organs of touch, capable of noting the difference between her own young and strange objects. The eyesight seems to be of secondary importance, or is used mainly in respect to large objects. The scorpions were always supplied with a liberal number of young and adult cockroaches and some crickets, although the latter were few in number since it was rather difficult to obtain them. Every two days water was sprinkled in the jar so that the sand was kept slightly moist. Under the described conditions the young scorpions were thriving very well and they grew considerably stouter. During the latter days of August I noticed that the young scorpions did not consume as many cockroaches as they had before and that they had become more sluggish. During the night from September 2 to 3, three scorpions molted for the third time, another molted at noon of the 3d, many more molted on September 4, six on the 8th, three on the 12th, and the last one passed the third molt on the 26th. Shortly before and during the process of molting, and for several days

after each molt, the scorpions were rather sensitive and irritable. During the third molt one scorpion died, on September 5, and two on September 9; in the process of molting the specimens were unable to cast off the old skin and were found dead. The last two dead scorpions I found partially buried in the sand, from which fact I concluded that they were trying to get into a moister place for the purpose of molting since all the other scorpions also showed a preference during molting for a fairly moist place in the jar, a cavity under a piece of bark. It seems that during molting the conditions of humidity must be absolutely right, so that the skin can be cast off readily. If the surroundings are too wet or too dry, molting will not proceed normally. Furthermore, it seems that the molting process takes place whenever the physical development has reached a certain stage. When that stage has been reached, and the conditions are not what they should be, the process cannot be delayed until later but must take place; if this is not possible the scorpion must perish. The molting process seems to be identical to that in the grapsoid crabs. The skin is ruptured around the anterior and lateral edges of the carapace due to internal pressure. By very strenuous contortions and exertions, the mandibles are first extracted, later the chelipeds follow. By still more strenuous efforts the anterior part of the body pushes forward and partially out of the old skin, then the legs are pulled out, and finally the whole scorpion wriggles out. The newly molted creature is extremely soft and very pale semi-translucent, grayish pinkish in color. It assumes a resting position after the molt, and if not molested remains in that position from one to several days, until it has hardened somewhat. On Plate 2, figs. 1 to 3, I have shown three exuviæ of the third molt of three individuals, in order to demonstrate the relative differences between them. Up to the third molt I had killed, intentionally, eight of the young scorpions in different stages, and preserved them in alcohol for further study. Three scorpions died or were killed during the fourth instar, so that there remained a total of twenty-one. Since the original jar had become rather crowded, and as I noticed that the young scorpions evidently preferred to have their surroundings more moist and humid, I separated all the young ones from the mother scorpion, placed them in several jars containing also moist sand at the bottom and a large piece of bark for hiding, and covered the jars with glass plates in order that the air in the jars was

always very humid and laden with moisture. The young scorpions I fed mostly with small to half-grown cockroaches; at times I injured adults of the latter slightly by squeezing them, so that the scorpions were able to subdue them more quickly. Under the newly modified conditions all of the scorpions were apparently well and were perfectly able to secure the food necessary for their maintenance. From October 4 to 6, five specimens molted for the fourth time. Seven other individuals passed the fourth molt between October 8 and 12. The rest of the young ones molted for the fourth time at very irregular intervals, the last one on March 10, 1926.

On Plate 2, figs. 4 and 5, are shown the fourth exuviæ of two specimens, demonstrating the slight individual differences in size.

During the period of the third molt, and in a more marked degree during the fourth instar, and still more so thereafter, it is clearly to be seen that the growth of the various individuals becomes more and more irregular as they generally advance in age. This fact is better demonstrated in Table 1.

TABLE 1.—*Showing dates of molting of young scorpions born on July 25 to 26, 1925.*

FIRST MOLT.

Date.	Number of specimens that molted.	Remarks.
1925		
August 3	33	Length of first instar, eight days. One specimen killed.

SECOND MOLT.

1925		
August 9 to 12	32	Minimum length of second instar, 6 days. Maximum length of second instar, 9 days. Eight specimens died or were killed.

THIRD MOLT.

1925		
September 3	4	Minimum length of third instar, 25 days.
September 4	10	Maximum length of third instar, 45 days.
September 8	6	One placed in alcohol and two died.
September 11	3	
September 26	1	

TABLE 1.—*Showing dates of molting of young scorpions born on July 25 to 26, 1925*—Continued.

FOURTH MOLT.

Date.	Number of specimens that molted.	Remarks.
1925		
October 4	3	Minimum length of fourth instar, 31 days.
October 6	2	Maximum length of fourth instar, 165 days.
October 12	7	One died.
November 14	2	
November 22	1	
November 28	1	
December 4	1	
1926		
January 10	1	
January 28	1	
February 6	1	
March 10	1	

FIFTH MOLT.

1926		
January 21	6	Fifth instar approximately 114 days.
January 24	2	One of January 21 placed in alcohol; three died.
February 6	4	
February 8	1	
February 15	1	
February 24	1	
March 10	1	
March 18	1	
March 30	1	
April 7	1	
April 24	1	

SIXTH MOLT.

1926		
April 10	1	Sixth instar approximately 75 days.
April 13	2	Three died.
April 14	1	
April 17	1	
April 19	1	
April 25	2	
May 5	1	
May 12	1	
May 21	1	
June 27	1	
July 26	1	
July 30	2	
September 2	1	

TABLE 1.—*Showing dates of molting of young scorpions born on July 25 to 26, 1925*—Continued.

SEVENTH MOLT.[a]

Date.	Number of specimens that molted.	Remarks.
1926		
July 5	1	Seventh instar approximately 85 days.
September 1	1	The scorpion that molted on September 1 had one cheliped injured during molting and died.
September 11	1	
September 12	2	Another of September 11 died during molting.
September 22	1	
September 25	1	
September 26	1	
November 1	1	

[a] On February 8, 1927, there are eleven scorpions still alive and healthy, seven of which are adults and four are still in the seventh instar.

Table 1 shows clearly that thirty-three young scorpions (one I killed intentionally for preservation in alcohol) all molted at about the same time, on August 3, the first instar lasting eight days. The second molt of thirty-two specimens (one more had been killed) extended over a period of three days. The third molt of twenty-four specimens extended over a period of twenty-three days. The fourth molt of twenty-one specimens extended over a period of one hundred sixty-five days. The fifth instar of twenty specimens can be calculated at approximately one hundred fourteen days. The sixth instar can be considered at seventy-five days. On July 5, 1925, one individual molted for the seventh time and thus reached the adult stage. Eight other individuals molted for the last time on the dates given in Table 1. The newly molted adult is very pale reddish or brownish gray, becoming darker from day to day. Fifteen days after attaining the adult stage, the color is dark castaneous. As the individual grows older the color becomes more piceous until it is black. The newly molted adult was extremely irritable and at the slightest provocation was ready to fight. About eight days after reaching the adult stage it was sufficiently hardened to take food. In the method of feeding on a cockroach, it acted somewhat differently from its mother which I had observed many times. The cockroach was not eaten up entirely but was chewed up into small fragments and the juice extracted. Then the fragments were left in the shape of an

irregular roundish lump of about half or three-quarters of a centimeter in diameter. Plate 3, fig. 1, shows a specimen a few days before the seventh molt, and fig. 2, the exuvia of the seventh molt.

Another noteworthy fact, well demonstrated by Table 1, is the extreme irregularity of growth of the young scorpions during the fourth and following instars, as manifested by the respective molts. The young were separated from the mother on September 3. Up to that time the food was mostly secured and killed for them by the mother, but after the last-mentioned date all of the young ones had to shift for themselves. Certain individuals, which for one reason or another had attained greater strength, were better fitted for the struggle for existence. Thus they were able to obtain the best and largest amount of food more easily. Furthermore, they were able to retain the lead once obtained and, in fact, increased the latter as they grew older.

The experiments described in this paper demonstrate that one specimen of this species of scorpion reached the adult stage in three hundred forty-five days, and that eight specimens reached the adult stage in from four hundred three to four hundred sixty-four days, while four specimens have not yet undergone the seventh molt.

The mother scorpion died on May 24, 1926. She manifested no symptoms of sickness before dying. It seems reasonable, therefore, to suppose that her life had run its natural course. It is safe to calculate that the life of this species of scorpion, based on the data contained in this paper, may be assumed as being not less than two years and possibly three.

Unfortunately, owing to my departure in the near future for Europe, it will be impossible to continue the study of these scorpions. Up to the present time (February, 1927), the above-mentioned adults have manifested no signs of courtship or other actions which could be interpreted as indicative of an approach to a mating period.

ILLUSTRATIONS

[Photographs taken by W. Schultze and E. Cortes. All figures natural size. * Indicates taken from a living specimen.]

PLATE 1

FIG. 1. *Palamnaeus longimanus* Herbst (?), female with thirty-four young ones.*
2. Young scorpion one day old.*
3. Young scorpion about four days old.*
4. Young scorpion after first molt.*
5. Exuvia of second molt.
6. Exuvia of second molt.

PLATE 2

FIG. 1. Exuvia of third molt.
2. Exuvia of third molt.
3. Exuvia of third molt.
4. Exuvia of fourth molt.
5. Exuvia of fourth molt.
6. Exuvia of fifth molt.
7. Young scorpion during sixth instar, shortly before sixth molt.*
8. Exuvia of sixth molt.

PLATE 3

FIG. 1. Young scorpion during seventh instar, shortly before seventh molt.*
2. Exuvia of seventh molt.

PLATE 4

FIG. 1. Old mother scorpion (Plate 1, fig. 1) with the young ones removed.
2. Mother scorpion with thirty-four young ones (lateral view.)*

PLATE 1.

PLATE 2.

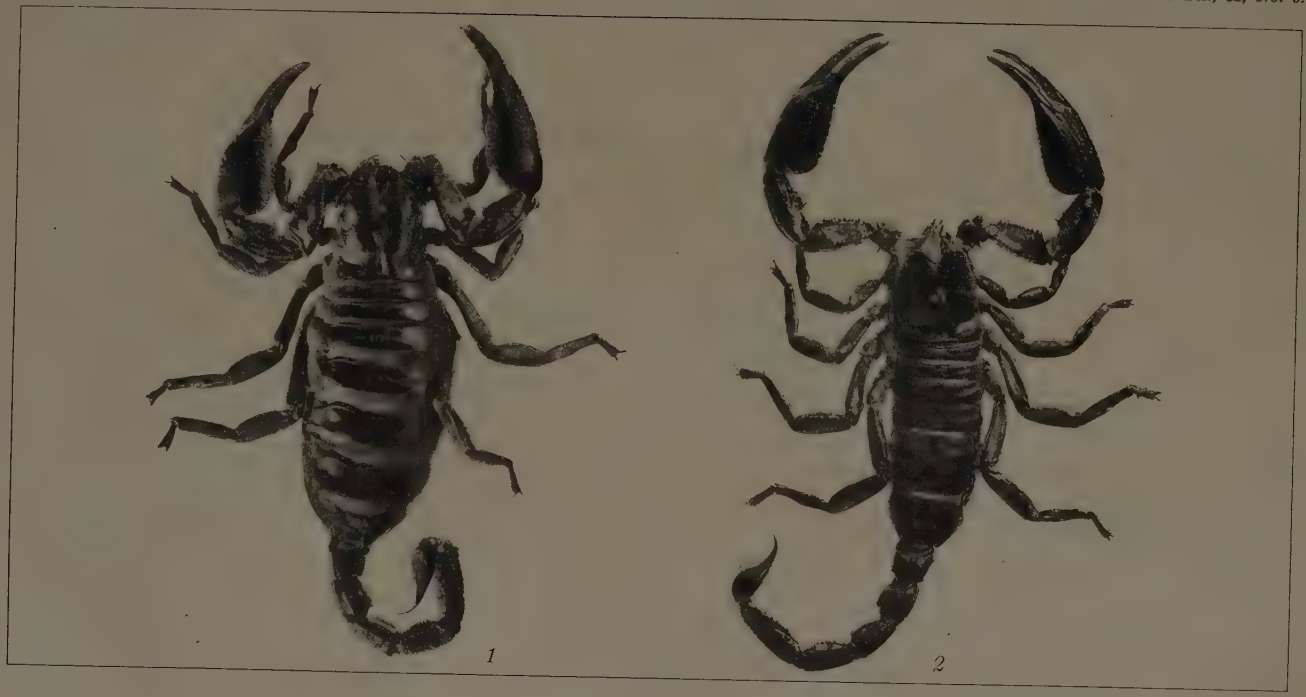

PLATE 3.

PLATE 4.

SPOLIA MENTAWIENSIA: HOMOPTERA-FULGOROIDEA

By C. F. Baker

Of Los Baños, Laguna, Philippine Islands

WITH AN INTRODUCTION BY

C. Boden Kloss

Director, Raffles Museum, Singapore

ONE PLATE AND TWELVE TEXT FIGURES

INTRODUCTION

By C. Boden Kloss

The Mentawi group, to the west of Sumatra, consists of the Islands of Siberut, Sipora, and North and South Pagi. The first and northernmost is larger than the other three (which are fairly equal in size) put together.

Except for the Rhopalocera of Sipora scarcely anything was known of their entomology until I visited Siberut and Sipora during September-November, 1924, accompanied by Mr. N. Smedley, assistant curator of the Raffles Museum, Singapore, and Dr. H. H. Karny, assistant entomologist, Zoölogical Museum, Buitenzorg, Java, with a party of native collectors. I have, as usual, to thank the Government of Netherlands India for the assistance and facilities afforded.

The islands are not very pleasant collecting ground; they are mostly swamp, out of which rise hills nowhere more than 1,500 feet high and generally difficult to get at, being surrounded by soft ground. The sago palm is common. The native villages are situated on the banks of rivers some distance up-stream, and there are scarcely any paths except those made by the Dutch military posts; they are generally through flat land and are often untraversable owing to floods. There is much rain throughout the year. The islands are unhealthy; in spite of systematic employment of quinine and other precautions, all the members of a party of fifteen, except myself, suffered from malaria, either on the islands or soon after leaving them.

The group lies parallel to the west coast of Sumatra and about 60 to 80 miles distant. Siberut is about 70 miles long and about 30 broad, and its northern extremity is on latitude 1° south.

The islands are apparently connected with each other by a sea bottom of less than 100 fathoms, and most bathygraphical charts show a connection with Sumatra, via the Batu Islands to the northeast, by a narrow ridge of similar soundings; but I am inclined to doubt that this ridge is unbroken, as indicated, for the faunas of the groups differ greatly, while, though the Mentawi Islands possess a much richer mammalian fauna than the undoubtedly deep-water islands of Simalur and Engano at the extremities of the western Sumatran chain of islands, the fauna is much more peculiar and differentiated than is that of Nias Island, also represented as being within the 100-fathom line. Whatever the depths may be, they certainly are not those of the shallow Sunda shelf (less than 40 fathoms) on which stand almost all the land masses of Malaysia; that is, the Peninsula, Sumatra, Java, Bali, Borneo, Palawan, etc.

Apart from the connecting ridge the group is surrounded by depths of 100 to 500 fathoms of water; further, everywhere directly between it and Sumatra lies the long Mentawi Basin, with depths of 500 to 1,000 fathoms. Such conditions render several of the western Sumatran islands, in spite of small size and lack of height, zoölogically quite as distinct from each other and from the rest of Malaysia as the larger areas of that subregion are from each other.

The islands are forested all over except for the plantations of the natives, and our material was obtained from various localities near the Government stations of Siberut in the island of that name, and Sioban in Sipora; it came from the seashore, low-lying ground, swamps, cultivated areas, and from such hills as were accessible.

During the journey to and from the islands we also made small collections of insects at Padang, western Sumatra, on Pulau Tello, one of the shallow-water Batu group to the north of Siberut, and on the Pagi Islands, where Doctor Karny also spent several days.

As reports on the various collections obtained are prepared they will be published in various journals under the general title "Spolia Mentawiensia."

The following have appeared to date:

Spolia Mentawiensia: Flora. H. N. Ridley, Kew Bulletin of Miscellaneous Information, No. 2 (1926) 56–94.

Spolia Mentawiensia: Birds. F. N. Chasen and C. Boden Kloss, Ibis (April, 1926) 269–305, pl. 3 and fig. 10.

HOMOPTERA-FULGOROIDEA

By C. F. Baker

FULGORIDÆ S. STR., EURYBRACHIDÆ, LOPHOPIDÆ, DICTYOPHARIDÆ, FLATIDÆ, RICANIIDÆ, ISSIDÆ, TROPIDUCHIDÆ

The small but interesting series in these fulgorid families is largely composed of more or less widely distributed Malaysian species. Several apparently undescribed species occur in the lot, but none of these can with safety be said to be certainly endemic or peculiar to the Mentawi group, due to the fact that but a very insignificant portion of the homopterous fauna of Sumatra or other Malaysian areas is yet known. No part of the world is richer than Malaysia in Homoptera. Collectors have usually given but little attention to the immense number of species occurring everywhere, either in the Fulgoroidea or the Jassoidea. Even the larger species, commonly of arboreal habit, are far more numerous than was formerly supposed; but, on account of their habits, they are collected with difficulty. It is, therefore, too early to venture any conclusion as to the distribution of these forms, in the case of the archipelago under discussion; that can only come after more comprehensive collections have been made in the various islands and also throughout western Sumatra. The present work, however, will add a number of records to the Mentawi list and also to that of the Batu Islands, a shallow-water group to the north of Siberut, where a small collection was made from which I have described three new species. The present expedition also obtained a few common species in the neighborhood of Padang, west coast of Sumatra, and these records are included herein. The last-named, however, are almost all species of wide distribution which occur also in the Mentawi group as well as in many other areas. While but forty-five species are recorded herein, there undoubtedly exist in the Mentawi Islands at least four hundred species pertaining to these families.

Records without name of collector are to be credited to the Expedition. Specimens collected by Dr. H. H. Karny are credited to him.

NEW SPECIES DESCRIBED IN THIS PAPER

Lophops mentawiensis sp. nov., Siberut, Mentawi Islands.
Trobolophya batuensis sp. nov., Pulau Tello, Batu Islands.
Melicharia karnyi sp. nov., Sumatra and Mentawi Islands.
Seliza siporensis sp. nov., Sipora, Mentawi Islands.

Detya batuensis sp. nov., Pulau Tello, Batu Islands.
Thabenoides smedleyi sp. nov., Pagi, Mentawi Islands.
Paratetrica distanti sp. nov., Pulau Tello, Batu Islands.
Daradax robustus sp. nov., Sipora and Siberut, Mentawi Islands.
Isporisella siporensis g. et sp. nov., Sipora, Mentawi Islands.
Garumna melichari sp. nov., Sipora, Mentawi Islands.

ENUMERATION OF THE SPECIES

FULGORIDÆ s. str.

FULGORA OCULATA Westwood. Plate 1, fig. 1.

This common and variable Malaysian species is represented by one rather deeply colored specimen from Siberut Island.

EUPHRIA DISCOLOR Guerin. Plate 1, fig. 3.

A single specimen of a form of this Sundanese species is labeled "North Pagi Island" (*Karny*).

SCAMANDRA ROSEA Guerin. Plate 1, fig. 4.

A small variety of this widespread Malaysian *Scamandra* is represented by eight specimens from Sipora and Siberut, one of the Sipora specimens bearing the number 227 (*Karny*).

PENTHICODES ATOMARIA Weber. Plate 1, fig. 6.

Two specimens from the adjoining Sumatran coast at Padang. This is a common Malaysian species.

PENTHICODES NIASENSIS Schmidt. Plate 1, fig. 5.

A series of specimens from Sipora and Siberut, and one from North Pagi Island, are referable to this Nias offshoot of *P. scutellata* White, the latter being represented by varying forms in many Malaysian countries.

EURYBRACHIDÆ

THESSITUS INSIGNIS Westwood. Plate 1, figs. 7 and 8.

This characteristic fulgorid of all Malaysian and Philippine regions, which so successfully mimics the bark and lichens of tree trunks, is represented by one specimen from Siberut. It is actually abundant in Malaysian forests, though not often seen unless specially sought, like many others of the larger Fulgoroidea. A small male from Padang is apparently referable to the same species.

LOPHOPIDÆ

APIA LINEOLATA Distant.

A large series shows this species to be abundant in the Mentawi group, specimens coming from Sipora, Siberut, and North Pagi. It was originally described from Singapore, where I have collected it. This species is discussed in a recent paper in

Treubia on the Malaysian representatives of this family, and there figures of it are presented. It will doubtless be found as commonly also in Sumatra, at the right season and on the proper food plant.

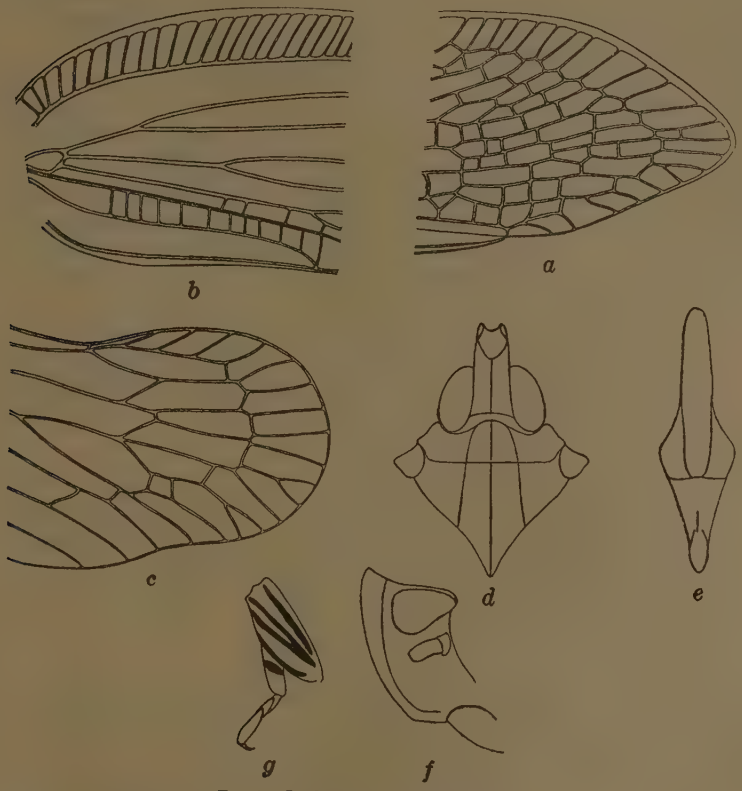

FIG. 1. *Lophops mentawiensis* sp. nov.

LOPHOPS MENTAWIENSIS sp. nov. Plate 1, fig. 14; text fig. 1, a–g.

Length, 10 millimeters; of head, 1 millimeter.

Female.—Testaceous, paler below. A broad smoky stripe passes from near base along subcosta to two-thirds length of tegmen, thence obliquely to apex where it is outwardly bordered with a blackish dash; costal area with about ten narrow oblique stripes which lie at nearly right angles to cross veins; with scattering irregular small darker flecks on corium and clavus. Wings pale smoky throughout. Lateral expansions of front, outwardly with about ten darker cross stripes; a dark line passes

from beneath eye caudad across pro- and mesopleuræ. Fore femora black striped (fig. 1, *g*); fore tibiæ black annulate, some of the spines on remaining legs conspicuously black (fig. 1, *d, e*).

In form of head more closely resembling *Lophops carinatus* Kirby but vertex longer in proportion to width (more than twice as long as wide at middle) and distinctly narrowed apically; median carina distinct to frontal border. Side view of face (fig. 1, *f*) very similar to that of *L. carinatus*, the lateral frontal expansions not so wide basally as in *L. zebra*. In frontal view (fig. 1, *e*) the sides of the front are not visible basally, as in *L. zebra* (visible to near extreme base in *L. carinatus*). Tegmina (fig. 1, *a*) somewhat acutely narrowed apically, though more elongately so than in *L. zebra*, and quite distinct in form from *L. carinatus;* with several distinct cross veins in clavus. Venation of wing as shown in fig. 1, *c*.

Described from five specimens from Siberut Island. The type and two cotypes returned to Raffles Museum, two cotypes in Baker collection.

DICTYOPHARIDÆ

MIASA RUBROVITTATA Schmidt.

The typical form of this species, as described by Schmidt from Java and Sumatra, appears to be common in the Mentawi group, specimens coming from Sipora, Siberut, and North Pagi. The genus is one of several in this family that are highly characteristic of Malaysia.

CENTROMERIA SPEILINEA Walker.

A common and widely distributed Malaysian species to be expected everywhere. Specimens come from Sipora, Siberut, and North Pagi Island.

TROPIDOPHORA JAVANA Lethierry.

This specimen is common throughout Java and Sumatra. Five specimens come from Siberut Island.

TROBOLOPHYA BATUENSIS sp. nov. Text fig. 2, a–e.

Length, female, 5.75 millimeters; male, 5.

Color pale testaceous (doubtless pale green in life), tegmina and wings hyaline, veins fuscous. Side of head above eye with a small indistinct dark mark or unicolorous. Vertex apically with two small black longitudinal dashes.

Apparently very close to *T. jacobsoni* Melichar,[1] but not agreeing with either description or figures of that species as figured by Melichar (f. 2).

Lateral margins of vertex (fig. 2, *c*) concave, leaving sides of front broadly visible in dorsal view, length of intraocular portion equaling that of anteocular. In side view (fig. 2, *e*) the angle between vertex and front is slightly less than a right angle. Sides of front (fig. 2, *d*) outcurved on basal half, broadest considerably before clypeus; venation of tegmina and wings as shown in fig. 2 *a*, *b*.

Described from six specimens from Pulau Tello, Batu Islands (*Karny*) and numbered 253, 254, 255. The type and three cotypes have been returned to Raffles Museum; two cotypes in Baker collection.

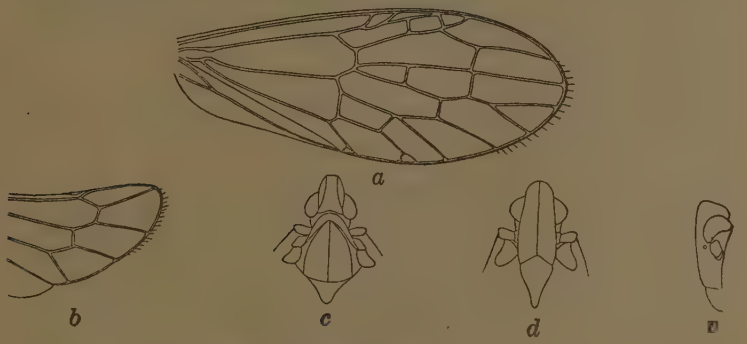

FIG. 2. *Trobolophya batuensis* sp. nov.

As remarked in the discussion of the species of this genus,[2] the details of structure in *T. jacobsoni* must be reviewed, and more material from the type locality (Nongkodijadjar, Java) is greatly needed. From what has been presented, however, it seems that *T. batuensis* is an entirely distinct species.

The genus *Trobolophya* has been redescribed from southern India by Distant[3] under the name *Stacotoides* and there placed in the family Tropiduchidæ. His species *typicus* appears to be quite distinct from *batuensis*. Distant's figures are apparently incorrect in several important respects; the cross vein at base

[1] Notes Leyden Mus. 36 (1913) 94, f. 1.
[2] Philip. Journ. Sci. 15 (1919) 303.
[3] Fauna Brit. Ind. Rhynch. 6 (1916) 50.

of inner apical cell appears to be omitted; the form of front should be reëxamined.

In the same year (1913) that Melichar described *Trobolophya*, but later in the year, Muir apparently described the same genus under the name *Neommatissus* [4] from Amboina, placing it in the Cixiidæ.

DICTYOPHARA PALLIDA Don.

Probably the commonest member of this family in the Far East. Widely distributed and variable. Specimens come from Siberut.

FLATIDÆ

LAWANA OPTATA Melichar forma. Plate 1, fig. 2.

One specimen from Padang. Distributed widely through Malaysia. I have specimens from Singapore and Penang. The species of this genus are highly variable and should be collected in large series in all regions.

NEPHESA COROMANDELIANA Spinola.

Two specimens come from Siberut and one from Sipora. Widely distributed.

NEPHESA ROSEA Spinola.

One specimen from Padang. Also widely distributed and highly variable.

MELICHARIA KARNYI sp. nov. Text fig. 3, c, e.

Length, female, 11.5 millimeters; male, 10.5.

Several specimens in the material sent me were labeled "Melicharia quadrata," by Doctor Karny, and apparently in conformity with his recent report of this species in southern Sumatra.[5] Fortunately, I have specimens of true *quadrata* from Ceylon, and comparison shows that this species (*karnyi*) is more nearly related to *M.* (*Anaya*) *fuscomarginata* than to *quadrata*. *Melicharia fuscomarginata* is an abundant Malaysian species, marked by a very broad, short face, like *quadrata; quadrata*, however, has a sharply right-angled sutural angle, while in both *fuscomarginata* and *karnyi* this angle is distinctly more than a right angle and obtusely rounded. The crown of head visible from above in *karnyi* (fig. 3, *e*) is much longer in proportion to width, and much farther extended in front of eyes than in either *quadrata* (fig. 3, *d*) or *fuscomarginata*, and the front is much longer in proportion to width (fig. 3, *a, quadrata; b, fuscomar-*

[4] Proc. Haw. Ent. Soc. 2 (1913) 267.
[5] Treubia 3 (1922) 4.

ginata; c, karnyi). In coloration *karnyi* resembles *fuscomarginata* more nearly than it does *quadrata*, being pale greenish (fading to ochraceous), the sutural and apical borders of tegmina very narrowly smoky.

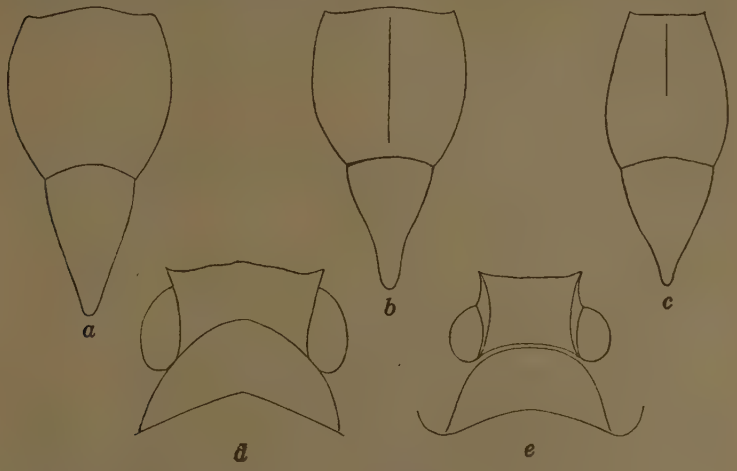

FIG. 3. *a, d, Melicharia quadrata* Kirby; *b, Melicharia fuscomarginata* Melichar; *c, e, Melicharia karnyi* sp. nov.

Described from four specimens, the type from Padang, with a cotype from Sipora (*Karny*), these returned to Raffles Museum. Two cotypes, one from Padang and the other from Siberut (*Karny*) in Baker collection.

This species appears to bear no relationship to species recently described by Schmidt or Jacobi.

MELICHARIA NIVEINA Walker.

Specimens come from Sipora (*Karny*), from South Pagi (*Karny*), and from Siberut. Widely distributed and common throughout Malaysia.

MELICHARIA FUSCOMARGINATA Melichar. Text fig. 3, b.

A large series of this common Malaysian species contains specimens from all of the islands visited, except Sumatra. Some of these specimens bore the label "Anaya n. sp.," though the species appears to be typical *fuscomarginata*. Distant and Melichar have placed the questionable genus *Anaya* in the Seliziinæ, though it is a close relative of the other "Ormenis" segregates and its real relationship seems to be with *Melicharia*, to which this species was formerly referred. It may be left in *Melicharia* until the question as to *Anaya* can be cleared up.

SELIZA SIPORENSIS sp. nov. Text fig. 4, a, b.

Length, 8 millimeters, width of tegmen, 4; width of head, 1.

Pale brown; tegmen with costal area and clavus somewhat darkened, and with a discal clouding opposite apex of costal area; a small round dark spot on corium opposite middle of claval suture; wings smoky, centrally paler.

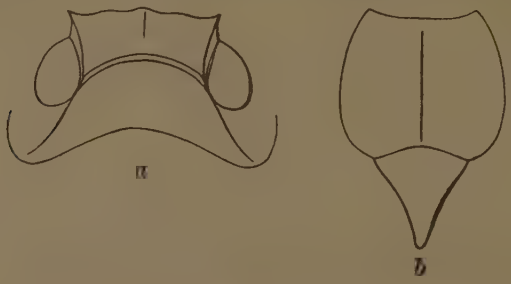

FIG. 4. *Seliza siporensis* sp. nov.

Crown of head (fig. 4, *a*) shorter than pronotum, its width at apex more than three times length at middle, anterior margin sinuate-truncate. Front (fig. 4, *b*) with sides strongly outcurved, its median length three-fourths of width at middle (fig. 4, *b*), a low, broad, rather indistinct facial carina continuous throughout from disk of clypeus to base of vertex. Tegmen very broad, breadth at middle more than half of length, squarely truncate apically, with the angles broadly rounded, the sinuations of margins distad of apices of costal area and clavus very shallow; costal margin not very strongly outcurved; granulations of clavus confined to basal and middle areas.

Described from one specimen from Sipora; returned to Raffles Museum.

ATRACIS LURIDA Melichar.

A single specimen of this Sundanese species comes from Siberut.

RICANIIDÆ

POCHAZIA MARGINATA Walker.

One specimen from Sipora. Throughout Malaysia.

POCHAZIA FUSCATA Fabricius.

Two specimens from Siberut, one from Sipora. Throughout Malaysia.

POCHAZIA SINUATA Stål.

Four specimens from Siberut. Another specimen from Siberut has the tegminal bands yellowish instead of the typical white, and belongs to the form *ochracea* Schmidt. Throughout Malaysia.

RICANIA MARGINALIS Walker.

One specimen from Padang. Throughout Malaysia.

RICANIA SIGNATA Stål.

Four specimens from Pulau Tello, Batu Islands, one from Sipora, and two from Siberut. Originally described from the Philippines, but afterward found to be generally distributed through Malaysia.

RICANIA DISCOPTERA Stål.

Four specimens from Siberut. A common Sundanese species.

RICANIA STUPIDA Walker forma. Plate 1, fig. 10.

One specimen from Siberut represents a form of this widely distributed and variable Malaysian species. The apical spot of tegmen is here smaller and less conspicuous.

RICANOPTERA MELLERBORGI Stål.

A large series of this very abundant Malaysian species contains many specimens from all of the islands visited.

DETYA FUSCONEBULOSA Distant. Plate 1, fig. 9.

A series of specimens of this well-marked species comes from Siberut. Of general distribution through southeastern Asia and Malaysia.

DETYA BATUENSIS sp. nov. Plate 1, fig. 12; text fig. 5, a–g.

A much smaller species than either *D. fusconebulosa* Distant or *D. sublineata* Walker, and with almost entirely unmarked, hyaline tegmina.

Length, 11 millimeters; length of tegmen, 10; width at middle, 5.

Pale ochraceous; facial carinæ fuscous but without dark granulations; small black spots on sides of head above eyes, on propleuræ, and on mesopleuræ; hind borders of abdominal segments infuscated; vertex with two lateral oblique black spots and mesonotum with four on either side (fig. 5, *e*). Tegmina hyaline, except for a few indistinct small smoky spots on subcostal and subapical cells, a small fuscous callous thickening

beyond end of subcostal cell and a similar, still smaller one in basal portion of cubital cell; veins fuscous, some at apex of costal area and about half of those on disk paler. Wings with an indistinctly smoky apical border.

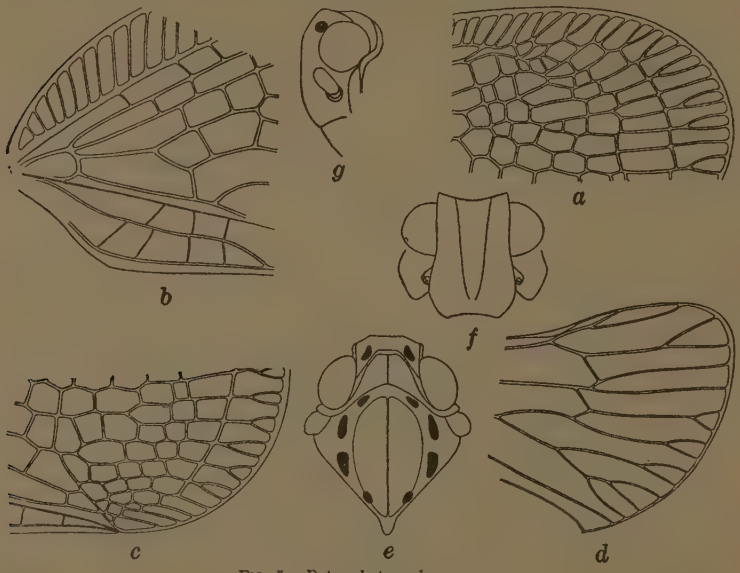

FIG. 5. *Detya batuensis* sp. nov.

Front (fig. 5, *f*) proportionally broader than in *D. fusconebulosa* Distant, the greatest width above clypeus nearly three-fourths of length. Proportions of head and thorax above, and head in lateral view are shown in fig. 5, *e*, *g*. Tegmina with cells before subapical series more numerous and much more regular (fig. 5, *a*, *c*) and the cross veins toward base more numerous (fig. 5, *b*); wings with but one fork in first apical vein (fig. 5, *d*).

Described from two specimens taken on Pulau Tello, Batu Islands. The type returned to Raffles Museum, one cotype in Baker collection.

GONIOPSIS MYSTICA Melichar. Plate 1, fig. 11.

A single specimen of this rather uncommon species is labeled "Pagi Ids.-Karny." The species was described from Singapore, where it was also taken by me.

ISSIDÆ

HEMISPHAERIUS IMITATUS Melichar.

A specimen each from Sipora, Siberut, and Pulau Tello, Batu Islands. Described from Sumatra.

GERGITHUS SIGNATIFRONS Melichar.

One specimen from Siberut. This is a male, 5 millimeters in length (Melichar gives 5.5 millimeters for both sexes). Melichar's specimens were evidently not fresh, since the lateral areas of front to either side of the blood red median area described by him as "blassgelblich" are, in life, pale bluish green and the apical connection is yellowish; the front apically and the clypeus medially are also red; there is a small blue-green spot on the propleura, a blackish spot on mesopleuræ, and the metapleuræ are reddish. In old or alcoholic specimens these colors might largely disappear. In other respects this specimen fits closely the description of Melichar.

GELASTYRA LATIFRONS Melichar. Plate 1, fig. 19; text fig. 6, a–e.

Two specimens, labeled "Pagi Ids.-Karny." This clearly marked species was described by Melichar from Sumatra, but also recorded from Burma, and from the misspelled locality "Mentawei, Sipopa." The latter undoubtedly refers to Sipora.

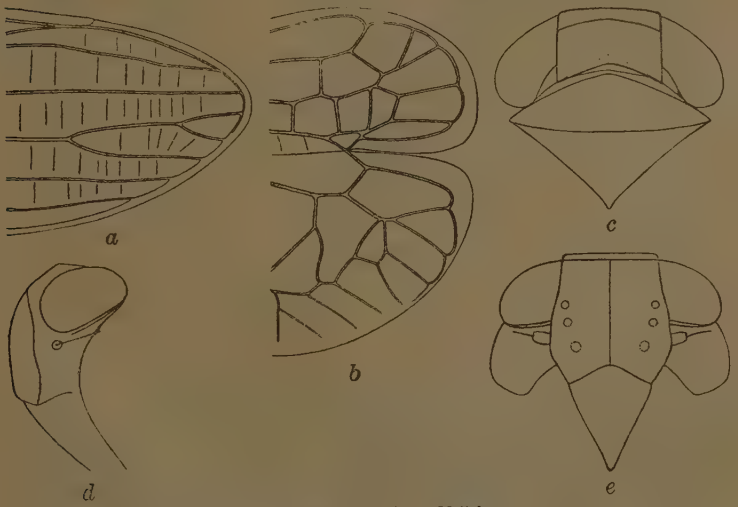

FIG. 6. *Gelastyra latifrons* Melichar.

In as much as no illustrations have been presented for this species, its important structural details are outlined in fig. 6, *a–e*. It is of the highest importance in the Issidæ to illustrate the venation of tegmina and wings carefully, since these furnish important classificatory characters.

THABENOIDES SMEDLEYI sp. nov. Text fig. 7, a–e.

Very similar to the chocolate brown *T. albinotatus* Distant, but without any of the paler markings described for that South Indian species.

Length, 6 millimeters.

Vertex (fig. 7, *c*) longer and narrower than in *T. albinotatus* and more extended and broadened before eyes, but of the same general form as in *T. albinotatus*. Pronotum acute apically. Front (fig. 7, *d*) longer, narrower basally, and basal margins more incurved, the lateral margins more strongly outcurved above clypeus. Cross veins of corium very indistinct; costal area (fig. 7, *a*) broader than subcostal. Wing (fig. 7, *b*) with very simple venation, but the two approximate veins immediately before lobar fold parallel, joined by a strong terminal loop and with several cross veins between them.

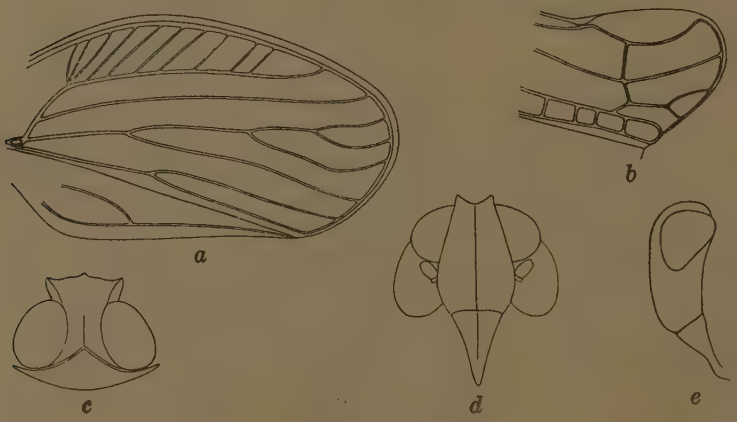

FIG. 7. *Thabenoides smedleyi* sp. nov.

Described from one specimen labeled "Pagi Ids.-Karny." Type returned to Raffles Museum. This species goes into *Thabenoides* better than into any other genus, though differing in several details, as described above. It apparently differs from *Thabenoides* most widely in wing venation, according to a sketch kindly sent to me by Mr. China of the

British Museum; but in as much as it so closely corresponds in other characters, it is for the present placed in this genus.

SARIMA sp.

One specimen in poor condition from Sipora (*Karny*). More material is necessary before proper determination can be made.

PARATETRICA DISTANTI sp. nov. Text fig. 8, a–e.

One specimen from Pulau Tello, Batu Islands, has the two fissural veins (fig. 8, *b*) coalesced apically and the front somewhat longer than broad, and these with its other characters place it in *Paratetrica*. There is a very faint indication of a median keel on vertex, though in certain lights this appears to be absent.

Length, 6 millimeters.

Pale brown. Front with two large pale spots adjoining middle of median carina and numerous small pale spots on either side adjoining lateral carinæ. Apical third of tegmina and extreme base paler, a broad albescent oblique band crossing corium at middle, and clavus apically. Wings slightly uniformly smoky.

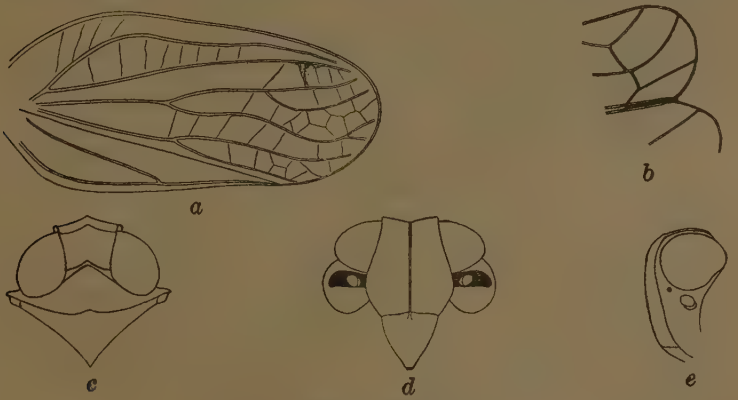

FIG. 8. *Paratetrica distanti* sp. nov.

Vertex (fig. 8, *c*) broader than long and somewhat acute angulate anteriorly. Front (fig. 8, *d*) a little longer than broad, rather suddenly broadened below eyes and angulately emarginate basally, with a strong median carina. The strongly declinate clypeus is heavily carinate basally. The antennæ appear very pale against a blackish irregular mark on propleuræ (over-emphasized in figure). The curve of head in lateral view (fig. 8, *e*) is quite even from base to apex, most prominent at

frontoclypeal suture. Cross veins in corium very weak and becoming more or less reticulate apically.

TEMPSA MALAYA Stål. Plate 1, fig. 18.

This common Malaysian species is represented by one specimen from Sipora and one from Siberut (*Karny*).

GLYPHOTONGA ACUMINATA Schmidt. Plate 1, fig. 17; text fig. 10, a–e.

One specimen of this remarkable species, described from Sumatra and Perak, Malay Peninsula,[6] was taken in Siberut (*Karny*). Since it has not been figured, some of its structural details are given here (fig. 10, *a–e*). The form of head (fig. 10, *c–e*) and of tegmina (fig. 10, *a*, *b*) are most distinctive.

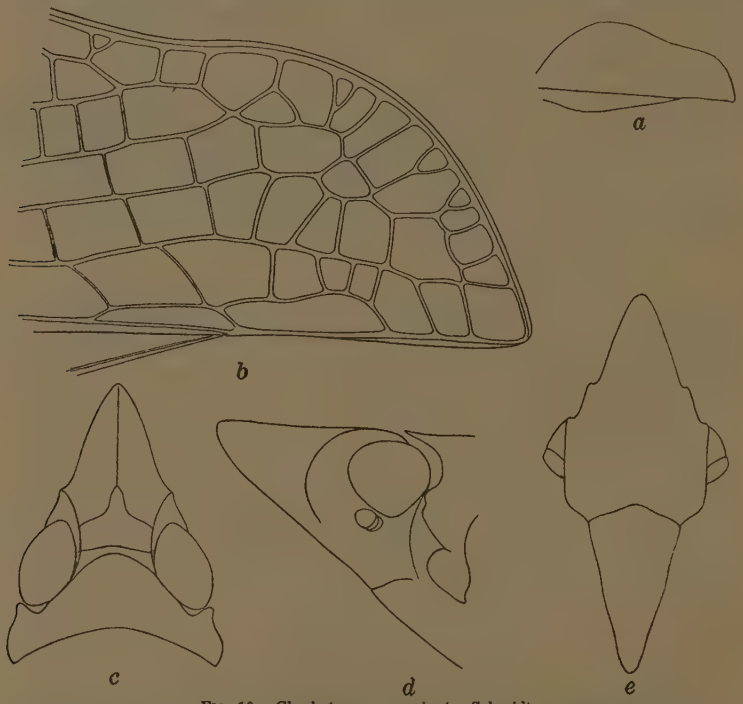

FIG. 10. *Glyphotonga acuminata* Schmidt.

This genus was redescribed under the name *Oxychara* by Melichar [7] and, strangely enough, placed in the American family Acanaloniidæ. Mr. China now calls my attention to the fact that it was also redescribed by Distant in 1914 under the name

[6] Stett. Ent. Zeit. 71 (1910) 187.
[7] Wyts. Gen. Ins. fasc. 182 (1923).

Neodelia. China also remarks (in litt.) that *Neodelia moultoni* Distant is *Glyphotonga cyardiformis* Melichar. The relationship of the genus appears to be with *Tonga*, and to the Tonginæ; apparently here should be referred also *Forculus* Distant, *Forculusoides* Distant, *Orthophana* Melichar, *Paratonga* Schmidt, *Oryxana* Distant, and *Hemitonga* Schmidt. They all have one or two subapical teeth on hind tibiæ, but this character is variable. In more stable characters they appear to be Issidæ.

TROPIDUCHIDÆ

DARADAX ROBUSTUS sp. nov. Plate 1, fig. 13; text fig. 11, a–f.

Length, male and female, 13 to 14 millimeters.

Pale green (to ochraceous in dried specimens), paler below; sides of front darkened, temples and vertex minutely mottled;

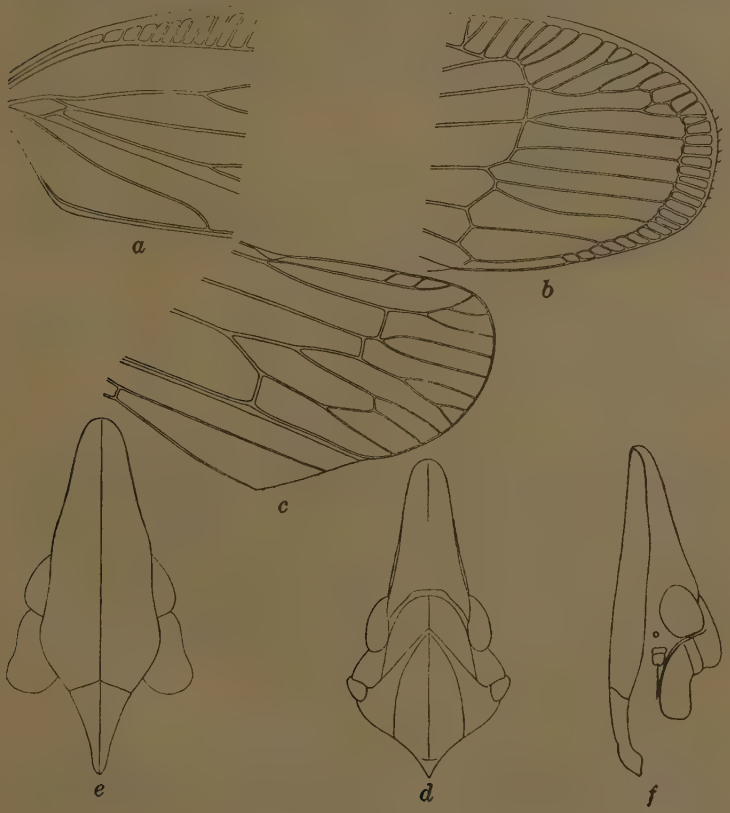

FIG. 11. *Daradax robustus* sp. nov.

a dark spot at tip of clavus and with fuscous mottlings in the apical area; corium otherwise clear unicolorous pale green.

Length of vertex one and a half times width between eyes, the narrowed apex (fig. 11, *d*) bluntly rounded; median carina more distinct on apical half. Front more than twice as long as broad below eyes (fig. 11, *d*), and with a strong median carina which continues on to clypeus, where it is somewhat angulate apically. Pronotum coarsely irregularly granulate, pitted, and with two approximate sharp longitudinal lateral carinæ behind eye. Tegmina and wings with venation as in fig. 11, *a–c*.

Described from one specimen from Sipora, two from Siberut (*Karny*), and two from Siberut collected by the Expedition. The type and two cotypes have been returned to the Raffles Museum; two cotypes in Baker collection. I also have specimens of the same species from Singapore and North Borneo. It appears to be abundant throughout Malaysia. It seems almost incredible that this species should not have been described before, but it is not *D. nasutus* Melichar, its only near relative in Melichar's monograph.

VARMA FERVENS Walker. Plate 1, fig. 15.

The collection contains a number of specimens of this common and variable Malaysian species from Siberut, Sipora, and Pulau Tello, Batu Islands.

EPORA SUBTILIS Walker.

This widely distributed Indo-Malaysian species is represented by several specimens from Siberut and Padang. It may be expected everywhere in Malaysia.

Genus ISPORISELLA novum

Nearest to *Isporisa* Walker, from which it differs as follows: Position of median carina of front marked only by a brown line on apical half but this resting on a broad median longitudinal raised portion of the surface which is nearly parallel-sided. The clypeus neither as long nor as wide as front, with a strongly raised median keel which apically is strongly angulate (in side view, fig. 12, *e*), the tip of clypeus thus delimited. Venation of wing and tegmen as shown in fig. 12, *a, b*.

Type, *Isporisella siporensis* sp. nov.

ISPORISELLA SIPORENSIS sp. nov. Plate 1, fig. 16; text fig. 12, a–e.

Length, 8 millimeters, female and male.

Sordid ochraceous, paler beneath. Pits of vertex and pronotum blackened, and two small black spots on mesonotum out-

side of lateral carinæ. Base of front with entire rondeur on to crown at apex of vertex, smoothly evenly swollen, shining black, and with a median crescentic yellow mark. Front below with two quadrangular red marks on either side. Clypeus dark at base. A horizontal black stripe across mesopleuræ and a black spot on metapleuræ. Femora with indistinct apical annulæ, and lateral stripes. Tibial spurs unicolorous. Tegmina faintly, evenly suffused with ochraceous, the wings hyaline, in some cases with a small dark spot on disk of corium before middle and another in clavus.

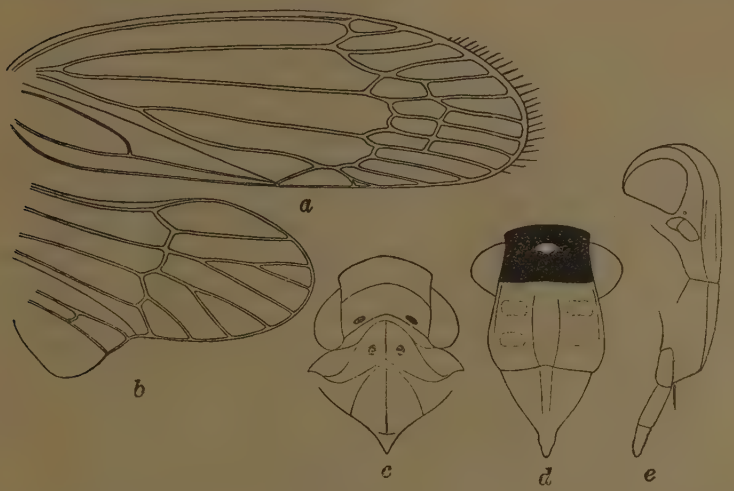

FIG. 12. *Isporisella siporensis* sp. nov.

Vertex deeply concave, its anterior margin high to meet the rondeur of the front, its length but little more than that of the moiety of the front seen from above (fig. 12, *c*), its width about three times the length. Front about a fifth longer than wide, the sides below eyes strongly outcurved.

Described from five specimens from Sipora. The type and two cotypes have been returned to the Raffles Museum; two cotypes in Baker collection.

GARUMNA MELICHARI sp. nov. Text fig. 13, a–e.

Length, 5.75 millimeters.

Very close to the Celebesian *G. lepida* Melichar, but larger. Coloration nearly the same, but the entire head above the lateral carinæ of front very smooth and shining, deep black (except

narrow lateral portions of anterior margin of vertex); a large part of the apical plane portion of front (except at basal reëntering angles, fig. 13, *d*) dark brown. Pronotum shining black anteriorly.

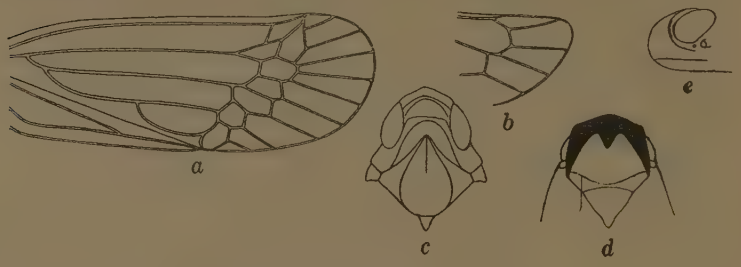

FIG. 13. *Garumna melichari* sp. nov.

The head is strongly flattened above and below, the lower part of face being nearly horizontal. The vertex stands in same plane as the base of front (fig. 13, *c*, *e*). Venation of tegmen and wing as in fig. 13, *a*, *b*. From Sipora Island; one example only.

Melichar described but one species of this genus; but there are several distinct species in Malaysia and the Philippines. All that I have seen have the entire rondeur of head and the vertex pale yellowish, with at most a narrow black band across plane portion of front. In all of the species the markings of tegmina are closely similar to those described for *lepida*. Type returned to the Raffles Museum.

ILLUSTRATIONS

[Photographs for plate, as well as reduced photographs of drawings for text figures, by Bureau of Science, Manila.]

PLATE 1

FIG. 1. *Fulgora oculata* Westwood, forma.
2. *Lawana optata* Melichar, forma.
3. *Euphria discolor* Guerin, var.
4. *Scamandra rosea* Guerin, var.
5. *Penthicodes niasensis* Schmidt.
6. *Penthicodes atomaria* Weber.
7. *Thessitus insignis* Westwood, female.
8. *Thessitus insignis* Westwood, male, forma.
9. *Detya fusconebulosa* Distant.
10. *Ricania stupida* Walker, forma.
11. *Goniopsis mystica* Melichar.
12. *Detya batuensis* sp. nov.
13. *Daradax robustus* sp. nov.
14. *Lophops mentawiensis* sp. nov.
15. *Varma fervens* Walker.
16. *Isporisella siporensis* sp. nov.
17. *Glyphotonga acuminata* Schmidt.
18. *Tempsa malaya* Stål.
19. *Gelastyra latifrons* Melichar.

TEXT FIGURES

FIG. 1. *Lophops mentawiensis* sp. nov.
2. *Trobolophya batuensis* sp. nov.
3. Three species of *Melicharia; a, d, Melicharia quadrata* Kirby; *b, Melicharia fuscomarginata* Melichar; *c, e, Melicharia karnyi* sp. nov.
4. *Seliza siporensis* sp. nov.
5. *Detya batuensis* sp. nov.
6. *Gelastyra latifrons* Melichar.
7. *Thabenoides smedleyi* sp. nov.
8. *Paratetrica distanti* sp. nov.
9. Omitted.
10. *Glyphotonga acuminata* Schmidt.
11. *Daradax robustus* sp. nov.
12. *Isporisella siporensis* sp. nov.
13. *Garumna melichari* sp. nov.

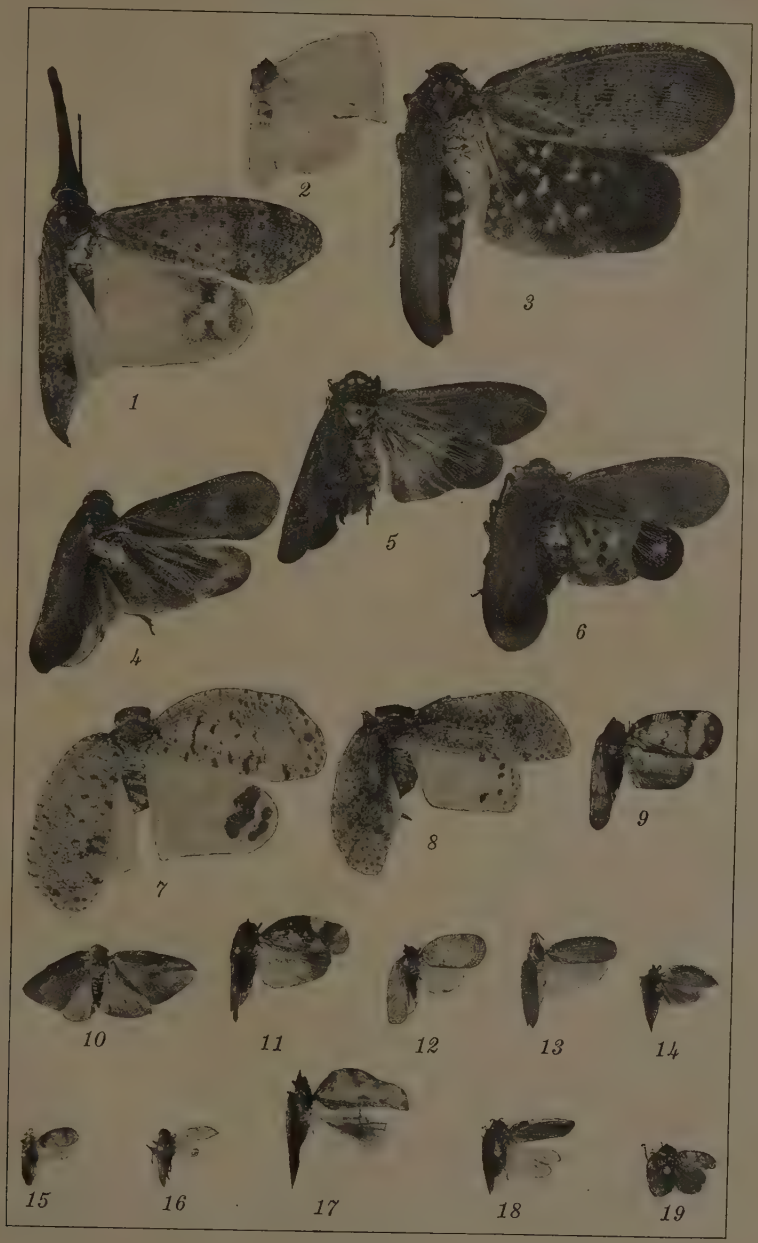

PLATE 1.

A NEW GENUS AND THREE NEW SPECIES OF PHILIPPINE FISHES

By ALBERT W. HERRE

Chief, Division of Fisheries, Bureau of Science, Manila

TWO PLATES

Genus MIROLABRICHTHYS novum

This genus can be distinguished at a glance by the remarkable proboscislike, fleshy, pointed tip on the premaxillary, and the scalation of the head.

The body appears elongate but is really deep, somewhat ellipsoid, everywhere covered with medium-sized ctenoid scales, those on the head much smaller and extending to tip of snout; very small scales cover the preorbital, maxillary, cheeks, opercles, and throat; the dorsal and anal are scaled basally and tiny scales extend upon their free portion; caudal covered with minute scales for half or three-fourths its length; the ventral is elongate, pointed, and one or two of the rays may be very elongate and filiform; mouth of moderate size, the maxillary not slipping under a sheath except anteriorly; upper jaw, or premaxillary, has a narrow band of fine teeth on each side posteriorly, becoming a large patch at anterior end of premaxillary and terminating in a stout canine; the lower jaw has very small teeth in narrow bands posteriorly, with a pair of canines at anterior tip, and one or two pairs of enlarged teeth a little way behind them; branchiostegals 6; pseudobranchiæ present. This genus is close to *Caesio* but is markedly differentiated from it.

Mirus, wonderful; *labrum*, lip; *ἰχθύς*, fish.

MIROLABRICHTHYS TUKA Herre and Montalban sp. nov. Plate 1.

Dorsal IX to XI, 14 to 16; anal III, 7; there are 45 to 48 scales in the lateral line, 5 between the origin of the dorsal and the lateral line, 12 between the lateral line and the origin of the anal.

The somewhat ellipsoid, rather deep body is scaled as given for the genus; dorsal and ventral profiles almost equally convex,

the depth 2.8 to 2.93 times in the length; the small pointed head is slightly concave on snout and is remarkable for the elongate, conical, pointed, fleshy tip projecting from the premaxillary, its length 3.11 to 3.4 times in the total length; the tip on snout contained about 2.5 times in the circular eye which is 4.5 times in the head, 1.4 to 1.66 times in the snout, and $1\frac{1}{8}$ to $1\frac{1}{3}$ times in the rather broad interorbital; posterior margin of eye more or less denticulate; mouth of medium size, oblique, the posterior margin of maxillary extending beyond eye, the greatest width of maxillary two-thirds that of eye, the lower jaw included, its tip coming to the base of the fleshy snout tip, and most of its length concealed by the broad maxillary; the teeth as given for the genus; the posterior margin of preopercle finely denticulate; the opercle has two flat spines on its posterior margin, the upper one larger and extending farther backward, with an elongated epidermal flap beneath them and extending still farther back; the first dorsal spine short, the others successively longer to the fourth, the rest subequal, about 4 times in the depth; the normal number of spines seems to be ten; the soft dorsal elevated, the posterior margin sharply angulate, the posterior portion elongate, the last four rays successively shortened, the fifth from the last equal or nearly equal to head, extending upon caudal when depressed; the second anal spine is the stoutest, the third the longest; the third or fourth anal ray is longest, shorter than the longest dorsal rays, not reaching base of caudal when depressed, the posterior margin of anal acutely angulate; depth of caudal peduncle almost equals its length, and is contained a trifle more than twice in head; caudal deeply lobate, the longest ray in both upper and lower lobes more or less filiform, equal to or greater than the depth; the pectoral elongate, about $1\frac{1}{3}$ times in the head; the ventrals elongate, pointed, the second and third rays often very elongate and threadlike, when they extend upon the anal and are more than the head or the depth.

Color in alcohol dusky reddish brown above, becoming paler and yellowish with reddish glints below, the fins all pale whitish yellow, without marks; a faint reddish or pinkish band extends from behind eye to base of caudal and another one from beneath pectoral backward along side to lower end of caudal base; a blackish blotch on opercle; a violet brown patch on basal portion of posterior two-thirds of soft dorsal. When fresh the color was brownish red above, the sides roseate, with two longitudinal

golden red bands, the fins golden, the patch on the soft dorsal violet.

Here described from the type and three cotypes, 84 to 94 millimeters in length, collected at Maricaban Island, in a school of *Caesio.*

Tuka, Tagalog for beak, in allusion to the projecting tip on the snout.

STEPHANOLEPIS NIGROLINEATUS Herre sp. nov.

Dorsal I–I, 29; anal 25.

The depth from the soft dorsal to origin of anal is 2 to 2.18 times in the length; body roughly oblong with pointed head, both much compressed laterally; head 3.2 to 3.27 times in the length; snout elongate with very convex dorsal profile, 1.5 times in head; the circular eye high up, about two-thirds its diameter below the upper profile of the convex interorbital space, 3 times in head and twice in snout; the lower extremity of the diagonal gill slit is just in front of the upper part of pectoral base; it is inclined at an angle of about 45°, its upper extremity beneath posterior margin of eye, its length twice in eye; the stout, backward-curved dorsal spine is over middle of eye, its length equal to that of snout; anterior surface of spine very rough with many small, upward-directed, pointed spinelets; on each corner of the posterior surface is a row of seven to nine stout barbs pointing downward and outward; the short, freely movable ventral spine has a terminal spine and two lateral spines on each side; first dorsal ray low, the next three elongated or very elongate and filiform, in one specimen about as long as head, the other rays uniform, low, equal to anal rays in height, less than an eye diameter in height; the anal rays all about the same height; the length of the subtruncate caudal equals snout, one and a half times in head, or twice eye.

Body covered with very small scales, each bearing on its posterior margin a slender spinelet or prickle; anteriorly these are very short and fine, but on the posterior half of body they become elongate and on caudal peduncle are stouter, recurved, forming a mat of conspicuous bristles.

Color in alcohol blackish gray, a little paler on throat, with nine black longitudinal lines on sides, extending from eye and breast back toward caudal peduncle; the fins are all concolorous and unmarked.

Here described from two specimens, 59 and 48 millimeters in length, collected by me on the reef at Bungau, Sulu Province.

GALLIONYMUS SPLENDIDUS Herre sp. nov. Plate 2.

Dorsal IV, 8; anal I, 7; pectoral 30; caudal 10.

Body stout, robust, wedge-shaped when viewed from above, the depth a trifle more than 4 times in the length, head very broad, its length 3 times in total length, its breadth four-fifths of its own length; the large eye equals the length of the narrow pointed snout and the width of the somewhat concave interorbital space; the stout preopercular spine contained 3 times in head; it terminates in three strong spines, the terminal one slenderer and straighter than the two anterior to it; the lower edge of spine smooth; the small circular gill opening is below and a little posterior to origin of lateral line.

The filamentous first dorsal spine reaches to base of last dorsal ray when depressed, and is contained 2.25 times in the total length; the other spines short, barely reaching origin of second dorsal when depressed, the second spine $1\frac{7}{8}$ times in head, the third spine almost as long, the fourth much shorter; second dorsal low, the rays of the posterior half more elevated than the anterior rays, except the last one which is low, reaching base of caudal when depressed, slightly greater than the depth, 3.75 times in the length, 1.25 times in the head; the two anterior and last anal rays shortest, the others of nearly equal length, equal to second dorsal in height and extending beyond base of caudal when depressed; the depth of the caudal peduncle is 5.625 times in the total length, its own length $\frac{7}{8}$ of its depth; caudal subtruncate, the lower rays longest, a little longer than head; the very broad pectoral equals the depth and is $\frac{11}{15}$ of the length of the head; the ventrals are somewhat pointed and extend back beyond origin of anal, but are shorter than the pectorals.

In life this bizarre little fish is most gorgeously and brilliantly colored. The ground color of the body is reddish brown, the head, trunk, and soft dorsal are covered with broad irregular bands of intensely brilliant green, the transverse bands on top of the head and between the eyes margined with black; a large deep indigo blue circular spot on belly between pectorals; a blue area on side of head between the eye, preopercular spine, and ventral sprinkled with brilliantly shining golden spots; top of head and throat pale yellowish; a large green ocellus, margined by a broad blue band on the spinous dorsal between second and fourth spines, the fin above this blue-black; the ground color of second dorsal dusky to blackish; the caudal has a broad terminal band of green, the rays are green, the membranes pale or yellowish with longitudinal spots and lines of deep blue; the anal

and ventrals dusky with irregular bands of deep blue; pectoral green with a broad basal crossbar of deep blue, eye blue, with a golden ring about the pupil.

In alcohol the green fades to blue or disappears; golden lines crossing the throat and breast from side to side, and not mentioned above, are changed to pinkish violet.

Here described from the type and only specimen, 45 millimeters long, collected by me on a coral reef at Bungau, in about 2 fathoms of water. A Samal datu, the headman of the village, when this extraordinary and fantastically marked little creature was placed in his hand, said; "I never saw anything like that before." It excited greater interest than I ever saw those keen-eyed observers, the Samals, display in a fish.

Splendidus, glittering, brilliant.

ILLUSTRATIONS

PLATE 1. *Mirolabrichthys tuka* Herre and Montalban sp. nov. × 1.5. (Drawing by M. L. Nievera.)
2. *Callionymus splendidus* Herre sp. nov. (Drawing by P. Bravo.)

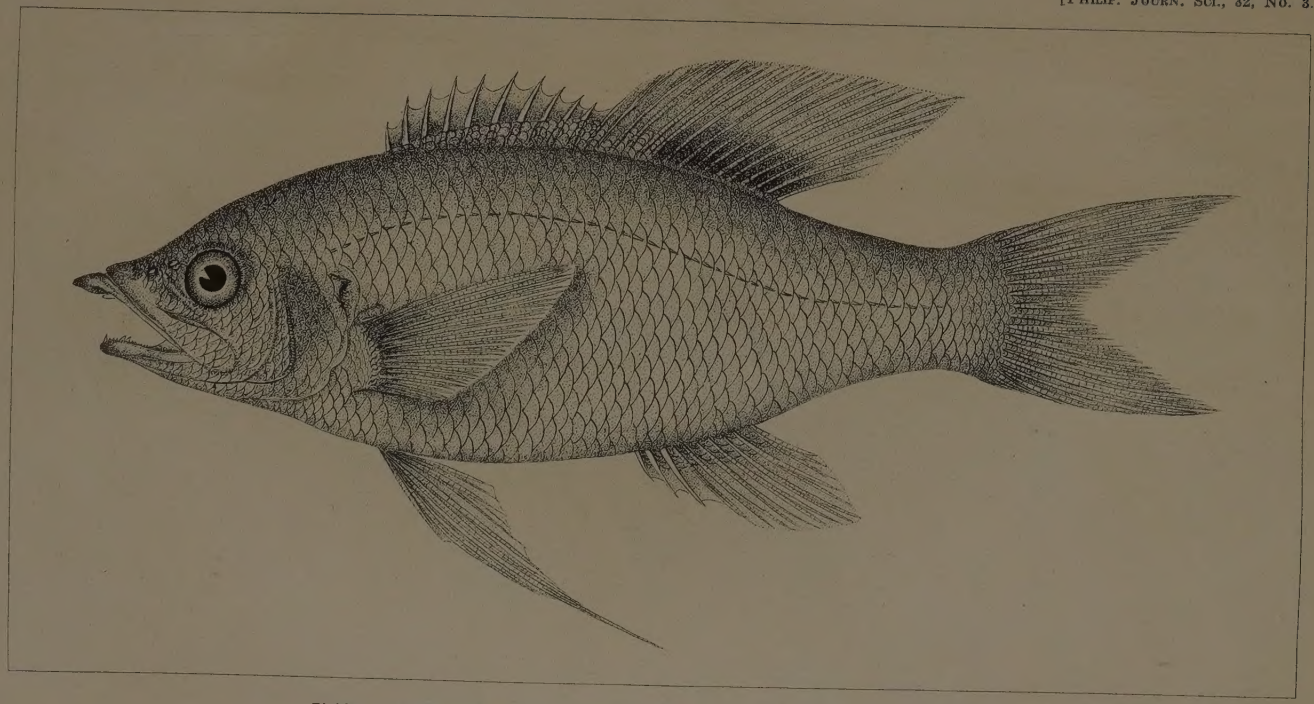

PLATE 1. MIROLABRICHTHYS TUKA HERRE AND MONTALBAN G. AND SP. NOV.

PLATE 2. CALLIONYMUS SPLENDIDUS HERRE SP. NOV.